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Abstract*

This paper compiles and analyzes several sources of information to shed light on the relationship between innovation and employment growth in the manufacturing industry in Chile in the last 15 years. Our overall conclusions are that process innovation is generally not found to be a relevant determinant of employment growth, and that product innovation is usually positively associated with an expansion in employment. These results seem to be similar regardless of firm size and hold for both low- and high-tech industries. Our findings reveal that in-house R&D (make only strategy) is positively related with employment growth. However, this is not the case for the sample of small firms. With respect to employment growth by types of workers, skilled vs. unskilled, the evidence is less robust. However, in-house R&D appears to favor employment growth for both types of workers in low-tech industries.

JEL Classification: D2, J23, L1, O31, O33.
Keywords: Innovation, employment.

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1. Introduction

Since the mid-1990s, successive governments in Chile have promoted innovation policies aimed at improving long-term productivity and economic growth. However, until now, neither an impact evaluation of these particular efforts nor a dynamic analysis of innovation as a whole has been carried out for analyzing the potential effects of innovation on employment.[1] This is a relevant empirical issue considering that theoretical considerations do not generate unambiguous predictions for this relationship. Moreover, the empirical evidence shows mixed results regarding the impact of innovation on employment growth, especially process innovation (Harrison et al., 2008).

The purpose of this paper is to analyze empirically the effects of innovation on employment growth using microeconomic data for Chile. This exercise is relevant for understanding, among other things, whether process and product innovation create or displace employment, how different innovation strategies affect employment, and how these effects vary by firm size and sectoral technological intensity. Several studies have been conducted on this issue, but they apply mostly to developed countries (Pianta 2005).

In this context, the present study has the following specific objectives: (i) to assess how different types of innovations create or displace employment in Chilean firms (focusing on the differential effects of product and process innovations on employment growth); (ii) to look at how different types of business innovation strategies influence the capacity of innovation to generate or destroy employment, and (iii) to determine whether the types of innovation (product or process) and innovation strategies have differential impacts across firms of different sizes and between high- and low-tech sectors. To analyze (ii), we consider two types of innovation strategies: make (in-house developed innovation) and buy (externally acquired innovation). Specifically, we analyze the impact of innovation on employment growth for small firms and (iv) how different types of innovations and innovation strategies affect the quality of employment as measured by skilled and unskilled employment growth. The differential impact for small firms is closely assessed.

There are important features of the Chilean economy that justify a study of this type. First, there are several available versions of the innovation surveys that follow the

[1] One exception is the study carried out by Benavente and Lauterbach (2008) estimating the impact of product and process innovation on firm employment growth using the 2001 Chilean innovation survey.

Community Innovation Survey (CIS) methodology (Oslo Manual) and allow a comparison of our results with other studies using similar surveys. This paper, uses mainly the innovation surveys carried out in 1995, 1998, 2001, and 2007. This information is complemented by firm-specific information obtained from the Annual Survey of Manufacturers (ENIA). This link between these sources of information is relevant given that innovation surveys usually provided very limited information on firm characteristics such as employment, sales, exports, and investment. Unfortunately, the same information for analyzing this issue in other sectors, such as services, is not available.[2]

Second, in recent decades, the Chilean government has implemented several policies aimed at increasing innovation and productivity. If innovation affects employment, these policies may have important effects on workers' welfare. Finally, as has been widely documented, since the financial crisis at the end of the 1990s, the Chilean economy has experienced a significant slowdown in productivity. After a period of high economic growth between 1986 and 1997, the rate of Chile's aggregate productivity growth declined dramatically in the last 10 years (Fuentes, et al., 2006). There is no consensus among policymakers and researchers on the main causes of this phenomenon. This study may shed light on the relationship between innovation, employment, and productivity.

A number of empirical analyses have examined the determinants of innovation using different versions of the innovation surveys carried out in Chile since 1995. Crespi and Katz (1999) and Crespi (1999) analyzed how industry and plant characteristics might explain differences in innovation using the first version of the survey. Benavente (2005) extended that analysis using three versions of the surveys. Álvarez (2001) and Álvarez and Robertson (2004) focused on trade-related variables as the main drivers of innovation activity. More recently, Benavente (2006), Álvarez et al. (2010), and Crespi and Zuniga (2010) estimated the impact of innovation on firm productivity. The study undertaken by Benavente and Lauterbach (2008) is the only one that analyzes the relationship between innovation and employment growth.

This paper extends the work of Benavente and Lauterbach (2008) in several dimensions, using additional innovation surveys and including new empirical questions. These authors found that product innovations affect employment positively and

[2] Since the 2001 Survey, there are additional sector included in the sample and not only manufacturing firms.

significantly, but process innovations do not. However, they did not look at the effect of innovation on employment composition (skilled versus unskilled). Nor did they analyze the effect of different innovation strategies on employment growth, the existence of potential differences between small and large firms, or technological intensity across sectors Moreover, their paper focuses on innovative firms only. This paper uses a different identification strategy that enables the full sample of firms to be used.

This paper is structured in the following way. The second section presents some qualitative and quantitative information about the Chilean economy, innovation policies, and the relationship between innovation and employment. It includes a summary of interviews and cases studies analyzing how innovation and employment are related in specific Chilean firms. The third section describes the datasets used in this paper. The fourth section presents the methodology and econometric results for the relationship between innovation and employment quantity. The fifth section focuses on the empirical analysis of innovation and employment quality, using estimations for skilled and unskilled workers. Section 6 presents the analysis of the effect of different business strategies on employment growth. Section 7 provides the main conclusions and findings. The paper concludes with policy implications.

2. The Chilean Economy

2.1 General Description

Chile has enjoyed remarkable economic performance in the last 15 years. With an average annual rate of growth slightly over 4 percent and annual population growth nearing 0.9 percent, today GDP per capita is close to US$13,000 (PPP). Some relevant variables of the Chilean economy and the context of innovation are summarized in Table 1.

Despite their volatility, unemployment on average has never reached two-digit figures. Last year, despite the effects of the financial crisis and the earthquake, the unemployment rate increased to almost 8 percent, only slightly higher than the 6.8 percent in 2005. Nevertheless, there is some consensus that the quality of human capital is relatively low and needs to be improved drastically in the years to come (Brandt, 2010). As can be seen in Table 1, only a quarter of the total labor force has tertiary education. If innovation—which is heavily based on well-trained employees—is at the core of the country's long-run economic growth strategy, it seems that the quality of human capital will, at some point, if not now, be an obstacle for maintaining high and sustained productivity growth.

Table 1. Evolution of Main Variables in Relation to Employment and Innovation

Indicator	1995	2000	2005	2010
GDP per capita (US$ PPP) (1)	9,140	10,470	12,172	13,057
GDP growth (between periods) (2)	-	4.2%	4.2%	4.2%
Labor productivity growth (growth between period averages) (3)	-	2.9%	1.5%	1.6%
Share of the population in the labor force (4)	39.1%	39.4%	41.5%	45.7%
Share of tertiary educated as a proportion of the labor force (5)	20.9%	22.8%	25.2%	25.2%
Unemployment (6)	4.7%	8.3%	6.9%	7.8%
Unemployment of the tertiary educated (7)	7.0%	6.4%	6.5%	9.2%
Innovation/GDP (8)	1.3%	1.0%	0.8%	0.9%
R&D/GDP (9)*	-	0.1%	0.2%	0.4%
BERD/GDP (10)*	-	0.1%	0.2%	0.2%

Notes: (1): constant 2005 international $; most recent: 2009; Source: World Bank. (2): growth of constant 2000 US$ GDP; most recent: 2009; Source: World Bank. (3): labor productivity = gdp/employment; most recent year: 2009; source: Central Bank of Chile. (4): most recent: 2008; Source: World Bank.(5): Labor force with tertiary education (% of total), most recent: 2007; source: World Bank. (6): most recent: 2008; source: World Bank.(7): Among those with tertiary education, unemployed/labor force; Source Casen 1998, 2000, 2006, 2009. (8): most recent: 2006: source: national innovation survey. (9), (10): most recent 2009; source: national innovation survey. * Year 1995 it's not informed do to a change in the methodology.

One important factor for enhancing economic growth is the amount of resources invested in developing and applying new ideas, products, and productive processes. Figures in Table 1 clearly show that expenditures in innovation and in R&D are not that high compared to other countries that have moved from middle-income to developed. Official figures show that R&D as a percentage of GDP was 0.4 percent in 2010 where private effort represents less than half of national expenditure.[3] Moreover, this low level of R&D investment is lower that would be expected according to Chilean per capita income. Several studies have shown that Chile suffers an innovation shortfall (Kharas, 2008; Maloney and Rodriguez-Clare, 2007). Maloney and Rodriguez-Clare (2007) show that even correcting for the structure of the economy, Chile invests relatively less in R&D than its counterparts in advanced economies.

[3] In 2010, a major methodological change was implemented in order to measure R&D at the private and also at the university level. The figures were then updated using this OECD accepted methodology back to 2000. This explains the overestimation shown for 1995 in Table 1.

2.2 Policy Landscape and Recent Evolution

Since Chile was accepted as member of the OECD group, it not only has instituted new procedures for calculating innovation and employment figures, but has also reorganized the institutional setup aimed at supporting R&D and innovation. Most of the implementation agencies related to innovation, R&D, education, and training fall under different ministries, as shown in Table 2. A Ministerial Commission on Innovation (CMI), established in 2010, has been attempting to resolve some of the coordination problems. These include dealing with program duplication, aggregating and consolidating budgeting processes, and designing new innovation-related programs. This is a new approach to decision making at the government level and a dramatic departure from the practice of previous administrations. The role played by the Ministry of Finance is far weaker than before, while the Ministry of Economy has taken the lead in this process.

Table 2 shows that the linkages among the different units especially related to innovation and employment are still weakly connected and there is plenty of room for improvement. By the same token, private institutions represented by firms, unions, and other collective agents, as well as training programs, do not actively participate in the decision making process associated with R&D and innovation efforts. This needs to be remedied in the Chilean case, as was revealed in some of the interviews of firm managers conducted for this study.

Table 2. Innovation and Employment Policies

Dimension	**Responsible agencies**	**Level of influence**	**Interactions and consultation mechanisms with other considered dimensions (4 point scale [a])**	**Private-public partnerships. Participation of the private sector (4 point scale[a])**	**Policy assessment mechanisms (4 point scale[b])**
Innovation	CORFO	National	2	2	2
Employment policies (emphasis on R&D, skilled employment)	Ministry of Labor, CONICYT/MIDEPLAN	National	2	2	1
Higher education (universities, vocational education)	Ministry of Education, CONICYT	National	2	2	1
Training policies (on the job, lifelong learning, etc.)	Ministry of Labor, SENCE	National	2	2	2

Source: Authors elaboration based on interviews.
Notes: (a) Scale: 1: Non-existent; 2: Low; 3: High; 4: Very high. (b) Scale: 1: Non-existent, 2: Some assessment (non compulsory) exist; 3: Assessments are inherent part but the results are not necessary taken into account in the (re)design of the program; 4: Assessments are made and results imply redesign/abandon of programs.

The National Council of Innovation for Competitiveness has played a major role in suggesting and promoting a more efficient institutional setup designed to improve the performance of the Chilean National Innovation System. It promoted the creation of CMI, and endorsed an aggregate budgeting process among all agencies involved in promoting science, technology, innovation, and entrepreneurship in the country. However, there are still several issues related to innovation and employment (and to other issues such as science, trade, and intellectual property rights) that need to be addressed. For example, with respect to upgrading the skills of the labor force, which can be considered a relevant constraint for innovation and productivity growth, even though there is awareness of this problem, the challenge is to create the institutional setup to solve the coordination problem. Some other challenges and potential actions to be taken are summarized in Table 3.

Table 3. Challenges, Strengths and Actions in Relation to Innovation, Employment Creation, and the Upgrading of Skills of the Labor Force

Dimension	Main challenges faced by the country	Challenges at the institutional/policy dimension	Main strengths	Actions taken/ to be taken
Innovation	-Low number of firms performing routinized R&D and innovation activities. -Weak interaction among main players involved in innovation. -Huge gap between technical feasibility and commercial viability in thinking and implementing innovation projects. -Several bottlenecks surrounding innovation activities that need public intervention to solve them.	-No further support towards selectivity and regional issues related with innovation. -Weaker role of the National Innovation Council. -Several coordination failures at the government level (isolated efforts)	-Consensus about innovation and entrepreneurship as a key solution for economic growth. -Few but highly visible successful innovation stories. -Implementation of new programs that emphasizes demonstration effects (start-up)	-Modification of the R&D tax credit law allowing in house R&D activities to be considered for benefits -Strengthen demonstration effects. -Institutional refinements (Millennium Initiative* now under the Ministry of Economy; a similar situation may happen with CONICYT)
Employment creation	- Labor quality rather than quantity is becoming a major issue in Chile. However, highly heterogeneous patterns across sectors. - Turnover rates have increased in recent years. - Exchange rate appreciation may affect tradable and non tradable sectors differently (Dutch disease)	-Labor market rigidities partly explain low TFP growth. -Discussion about labour markets issues are not related with productivity. -Low interaction of Ministry of Labour and other ministries.	-Job creation likely to persist in the next two years - Awareness that job quality needs more attention and innovation needs better trained workers.	- More resources allocated to training and competences certification programs. -Start up Chile may have an impact on new jobs most of them for highly qualified Chileans.
Upgrading of the labor force skills	-Shortage of graduates in S&T especially for natural resources based sectors.	-Lack of information (and those responsible to generate it) about needs of human resources at a sectoral level. -Disconnection between those who supply labour skills upgrading and the potential demand for them (information asymmetries)	-Awareness (public and private sector) of the existence of coordination problems.	-Creation of ad hoc councils to discuss ways to solve the coordination problems (at the government level and at the market one)

Source: Authors' elaboration based on interviews and previous work.
*Notes:** The Millennium Science Initiative (MSI) is a government entity whose main objective is to promote the development of cutting-edge scientific and technological research in the country, as a key factor for sustainable, long-term economic and social development. The MSI finances the creation and development of Centers of Research -Millennium Institutes and Nuclei- which are selected through public grant competitions for their scientific merits.

2.3 Views on the Relationship between Innovation and Employment

To complement the quantitative work shown in the following sections, we conducted several interviews with researchers, policymakers in relevant public agencies, and firm managers. The first part of the interview described the project and its main objectives. Interviewees were asked about their views regarding the relationship between innovation and employment, the main obstacles to innovation in Chile, the role of labor regulations and skill composition, and the differential impact of innovation strategies on employment. In the case of policymakers, the interviewees were asked whether or not public policies on innovation take into account the potential effect of these policies on employment. These interviews were applied to two researchers in academic institutions in Chile[4] and two highly positioned members of public agencies: Ministry of Economy and CORFO.[5]

The main findings from these interviews are summarized below:

- Consistent with the theoretical literature, there is some consensus that the effect of process and product innovation on employment might be different. All of them mention that the most likely effect of process innovation is to reduce labor demand and that product innovation—by increasing the demand for goods produced by the firm—has a positive effect on employment. However, the negative effects of process innovation are considered more relevant in the short run. Particularly people involved in public policy making believe that innovation—in a broad sense—has positive effects on firm competiveness and then on employment creation. Both of those interviewed are of the view that innovation—through the creation of new companies—favors employment growth in the economy.
- From these interviews, in general, it can be inferred that the effects of innovation on employment composition are considered important, but not necessarily from the standpoint of the formal skills of workers. Although academic researchers are influenced by ideas about skill-biased technological change, policymakers mention other relevant characteristics such as tolerance of uncertainty and capacity of integrating knowledge. In some cases, the effects of innovation on organizational

[4] Andrés Zahler (Universidad Diego Portales) and Daniel Goya (Universidad Católica de Valparaíso).
[5] Conrad von Igel (Ministry of Economy) and Cristobal Undurraga (CORFO)

structures are also thought to be important for thinking about how firms manage the consequences of innovation-driven changes within them.

- The potential negative effects on employment are not considered to be important obstacles to innovation. One aspect that was mentioned by all of those interviewed is related to cultural issues, for example the absence of appetite among entrepreneurs of small firms for undertaking innovation, conformity in maintaining a low-profitability business, the high social and financial costs of undertaking unsuccessful projects, and college graduates who are highly qualified but not interested in starting their own business.
- There is some agreement that labor regulations are not a significant obstacle to innovation, but the excess of bureaucracy and the current bankruptcy law are seen as serious impediments to the creation of new business. For policymakers, the existence of restrictions on foreign workers and part-time jobs are also considered to be factors that inhibit innovation in Chile.
- Regarding innovation strategies—make or buy—there is no uniform view about their consequences. This may be a reflection of the fact that the low levels of innovation in Chile and expenditure in R&D highly concentrated in large firms do not permit them to draw any definitive conclusions about this phenomenon.
- No evidence that innovation policy has had any specific effects on employment growth in Chile was found. In fact, the common view is that innovation increases firm competiveness in the long run and that it creates more jobs that those that are destroyed.

These views are generally consistent with those of firm managers in different sectors of the Chilean economy. We have chosen four firms to illustrate in detail the relationship between innovation and employment. Two of them were chosen using the following criteria. First, they are small firms with fewer than 50 workers. Second, they do not produce in the traditional export sectors of the economy. Personal contacts were used to contact the managers. In these first two cases, both managers graduated from the University of Chile and have more than five years of managerial experience. In the other two cases, we looked at firm data and contact information contained in the innovation surveys using two criteria. First, one of them should belong to a more traditional export sector and the other should be a producer in a domestic-oriented industry. In addition, we sought firms that had innovated in one of the aspects considered in the survey (product, process, and organizational innovation).

The interview format was developed and sent to each person to be interviewed two days prior to the interview. The case studies, presented in the Appendix, were structured around the following issues: main innovations undertaken by these firms, the relationship between innovation and employment, the obstacles to innovation, and views about innovation policies in Chile. Following are the main findings of these cases studies:

- Innovation does not appear to be associated with dramatic changes in employment in these firms, although the managers consider that the effect of innovation on employment creation or displacement depends on the type of innovation. Consistent with the view of researchers and policymakers, product innovation is considered to be more likely to create new jobs, while process innovation tends to displace workers, especially unskilled labor.
- However, this negative effect of process innovation can be minimized through worker training. In this context, some managers had a negative impression of the current training programs in the Chilean economy. This should be taken into account by government programs aimed at fostering innovation.
- There are still significant obstacles to innovation in the firms surveyed. Some of them are related to the lack of resources for undertaking innovation projects, while others are more linked to scant experience in taking advantage of government assistance programs. None of the managers interviewed, however, felt that the potential negative effect of innovation on employment has been a significant impediment to incorporating new productive processes. In fact, competitive pressures have spurred the incorporation of new processes or the development of new products.

In sum, researchers, policymakers, and managers believe that the effects of product innovation on employment growth are positive. There are some concerns, especially in the short run, regarding the potential negative effects of process innovation. However, it seems that once firms decide to introduce new products and processes, or policymakers implement new programs for fostering innovation, the potentially negative effects on employment are not considered to be of first-order importance. The following sections provide a more systematic analysis of the relationship between innovation and employment using a large sample of firms over the last decade in Chile. The next section describes the data used in this paper.

3. Data Description

The main source of information on innovation activities in Chile is the National Innovation Survey (EIT) carried out by the National Institute of Statistics. The survey has been conducted every three or four years since 1995. The questionnaire follows the guidelines of the Oslo Manual developed by the OECD (OECD, 1997). Although there has been some variation in the number and types of questions, the structure of the survey has remained similar across the different waves.

The questions are divided among the following sections: (i) the types of innovations that the firm has carried out in the past two or three years, (ii) the goals of those innovations, (iii) sources of the ideas of innovation, (iv) purchases of equipments, (v) obstacles to innovation, (vi) links with scientific and technological institutions, (vii) importance of innovation in firm business, (viii) cost and financing of innovation, (ix) expenditure in R&D, and (x) perspectives concerning future innovations.

We have access to four waves of the surveys—1995, 1998, 2001 and 2007—which have been matched with information from the National Annual Manufacturing Survey (ENIA) using a plant identification number. Due to problems originating in this identification number between the Innovation Survey carried out in 2005 and the ENIA, it was not possible to find a reliable matching between these two sources of information for that year.

Table 4 presents the descriptive statistics of the sample used in this paper. The total number of observations is 2049, with an average number of workers per plant of 215. Thirteen percent of the plants are foreign, and more than 50 percent of the plants are located in the Metropolitan Region of Santiago. Regarding innovation performance, about 30 percent of the plants report that they do not innovate either in product or in process, and 53 percent of them are product innovators. Note that more than 50 percent of these plants that introduce product innovations are also process innovators.

Table 4. Descriptive Statistics for all Manufacturing, 1993–2006

	Mean	Median	St. Dev.	Min.	Max
Number of observations	2049				
Distribution of firms (%)					
Noninnovators (no process or product innovations)	30.70				
Process only innovators (non-product innovators)	3.95				
Product innovators	53.44				
(of which product and process innovators)	51.05				
Number of employees at the beginning of (each) survey	215	111	292	10	3625
Foreign ownership (10% or more)	0.13	0	0.33	0	1
Located in the capital of the country	0.52	1	0.50	0	1
Employment growth (%) (yearly rate)					
All firms	-0.18	0.00	14.65	-67.43	62.14
Noninnovators (no process or product innovations)	0.80	0.00	14.59	-66.79	58.32
Process only innovators (non-product innovators)	2.12	3.62	14.02	-41.01	34.01
Product innovators	-0.52	-0.39	13.89	-67.43	58.59
Growth wage bill per worker (%) (yearly rate)	7.59	7.88	16.27	-127.22	112.61
Sales growth (%) (nominal growth) (yearly rate)					
All firms	6.50	6.90	16.91	-66.06	66.66
Noninnovators (no process or product innovations)	2.89	3.63	18.36	-66.06	58.16
Process only innovators (non-product innovators)	7.05	7.09	14.81	-40.00	43.56
Product innovators	8.49	8.63	15.51	-47.97	66.66
of which:					
Old products	-5.69	-4.17	17.51	-48.08	51.18
New products	14.2	10.5	14.0	0.1	64.3
Labor productivity growth (%) (yearly rate)					
All firms	6.68	6.47	18.36	-83.52	96.46
Noninnovators (no process or product innovations)	2.09	2.51	18.49	-83.52	59.69
Process only innovators (non-product innovators)	4.93	3.37	16.55	-27.93	63.53
Product innovators	9.00	8.42	16.83	-64.87	81.70
Prices growth (%)					
All firms	5.01	3.50	6.60	-10.87	36.38
Noninnovators (no process or product innovations)	3.81	2.91	5.50	-3.00	36.38
Process only innovators (non-product innovators)	5.03	2.91	8.18	-2.39	35.66
Product innovators	5.62	4.09	6.58	-10.87	36.38

Source: Authors' elaboration based on Innovation Surveys.
Notes: Sales growth for each type of firm is the average of variable g and averages for old and new products are the averages of variables g1 and g2, respectively. Prices computed for a set of industries and assigned to firms according to their activity

During this period, the average plant increased nominal sales by 6.5 percent (more than 1 percent in real terms approximately) and employment contracted by 0.2 percent. Employment and sales growth was higher for process only innovators (2.5 percent and 8.8 percent, respectively). While product innovators expanded sales by 8.2 percent, they experienced an average employment contraction of 0.5 percent. In terms of labor productivity growth, the data show an average increase of 6.7 percent. The growth rate was lower for noninnovators (2.0 percent) than the other groups, and larger for organizational change and product innovators, with growth rates of 9.7 percent and 8.7 percent, respectively.

Table 5 shows similar information for the sample of small firms, defined as employing 50 or fewer workers. The total number of observations is 652, with an average number of workers per plant of 26. The percentage of foreign plants (6.0 percent) is lower than the same figure for all firms (13.0 percent). Similar to the entire sample, about 50 percent of the plants are located in the capital of the country.

In terms of innovation variables, about 57 percent of the plants do not innovate either in product or in process. This is a larger figure compared with the sample of all firms. The percentage of product innovators is 34.2 percent, lower than the figure for all firms. In general, the comparison between both samples shows that small firms tend to innovate less than large firms.

The average plant employment growth for small firms was 1.5 percent, and nominal sales increased by 5.3 percent. Process only innovators experienced the highest increase in sales (9.1 percent), followed by organizational change innovators (8.2 percent) and product innovators (8.2 percent). The process only innovators were also the group of plants having the highest increase in employment growth, well above the rest of the firms.

There were also significant differences in labor productivity growth across firm size and types of innovators. Compared to the growth of the entire sample (6.7 percent), productivity in small firms only grew 3.9 percent. Among small plants, the highest labor productivity growth occurred in the organizational change innovators (9.8 percent), followed by the product innovators (6.7 percent). Similar to the case for all plants, the lowest productivity growth in small plants corresponded to noninnovators (1.5 percent).

Table 5. Descriptive Statistics for Small Firms in Manufacturing, 1993–2006

	Mean	Median	St. Dev.	Min.	Max
Number of observations	652				
Distribution of firms (%)					
Noninnovators (no process or product innovations)	57.52				
Process only innovators (non-product innovators)	3.68				
Product innovators	28.83				
(of which product and process innovators)	25.92				
Number of employees at the beginning of (each) survey	26.09	24	11.29	10	50
Foreign ownership (10% or more)	0.06	0	0.23	0	1
Located in the capital of the country	0.48	0	0.50	0	1
Employment growth (%) (yearly rate)					
All firms	1.45	0.00	15.22	-53.39	58.32
Noninnovators (no process or product innovations)	1.49	0.00	14.62	-49.04	58.32
Process only innovators (non-product innovators)	4.54	3.79	11.05	-13.88	34.01
Product innovators	1.83	0.00	14.96	-44.12	52.23
Growth wage bill per worker (%) (yearly rate)	6.47	6.34	15.21	-67.67	95.44
Sales growth (%) (nominal growth) (yearly rate)					
All firms	5.30	5.52	18.71	-65.94	63.93
Noninnovators (no process or product innovations)	3.08	4.18	18.86	-65.94	58.16
Process only innovators (non-product innovators)	7.61	9.02	11.14	-23.48	27.35
Product innovators	8.46	7.27	18.34	-43.39	63.93
of which:					
Old products	-5.75	-4.42	18.77	-46.75	38.51
New products	14.21	10.15	14.58	0.51	63.08
Labor productivity growth (%) (yearly rate)					
All firms	3.86	3.90	19.97	-83.52	96.46
Noninnovators (no process or product innovations)	1.58	2.22	19.17	-83.52	59.69
Process only innovators (non-product innovators)	3.07	5.85	10.97	-16.18	22.06
Product innovators	6.63	7.38	19.26	-64.87	68.85
Prices growth (%)					
All firms	3.62	3.85	18.85	-83.52	75.00
Noninnovators (no process or product innovations)	1.60	2.22	18.40	-83.52	59.69
Process only innovators (non-product innovators)	3.27	0.80	10.56	-11.89	22.06
Product innovators	6.43	7.38	18.12	-64.87	64.36

Source: Authors' elaboration based on Innovation Surveys.
Notes: Sales growth for each type of firm is the average of variable g and averages for old and new products are the averages of variables g1 and g2, respectively. Prices computed for a set of industries and assigned to firms according to their activity.

4. Innovation and Employment Quantity

4.1 Methodology

Since the literature suggests that the effect of innovation on employment generation depends on the relative intensity of displacement and compensation effects that may influence the demand for labor (Dachs and Peters, 2011; Harrison et.al, 2008; Hall et al., 2008; Peters, 2005), this section decomposes both effects. Hence, the basic model distinguishes two types of products, older and new. Thus, the change in employment can be divided into the part due to improving efficiency related to process and organizational innovation and the part due to the introduction of new products (product innovation). The quantitative analysis of innovation effects on employment follows the methodology developed by Harrison, et al. (2008) and applied in several other studies (Dachs and Peters, 2011; Hall et al., 2008; Peters, 2005). First, the following basic equation is estimated:

$$l = \acute{a}_0 + \acute{a}_1 d + \alpha_2 g + \tilde{o}$$

where l is total employment growth, g is real sales growth, and d is a dummy variable equal to 1 if the firm introduced either process or product innovations. Industry- and year-specific effects are included to control for unobserved heterogeneity at the industry level and common shocks to all firms. The model is also estimated including a dummy variable for product innovation and other for process innovation. As control variables, a dummy for firms located at the capital of the country and another dummy for foreign owned firms are introduced.

An initial problem with this approach is related to the fact that sales of new and old products are not directly observed in the data. Following Harrison et al. (2008), these variables can be computed based on information about (i) the share of new products in total sales, and (ii) the growth rate of total sales. More formally, the sales growth of new (g_2) and sale growth of old products (g_1) can be defined according to the following expressions:

$$g_2 = s(1+g) \quad \text{and} \quad g_1 = g - s(1+g)$$

where g is the growth rate of total sales and s is the share of new products in total sales.[6]

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[6] All nominal variables were transformed to real ones using a 3-digit deflator developed by Bergoeing et al. (2005). For the last years of the sample, these deflators were updated using the same methodology and data sources of these authors.

The initial and final period for computing growth rates depends on the way that questions about innovation have been designed in the different Chilean surveys. In the first three innovations surveys, the questions were related to the last three years. In the last available survey, these were related to the last two years. Employment and sales growth are computed as the annual rate of change to eliminate potential problems associated with differences in the timing of the innovation.

Unfortunately, the Chilean innovation surveys did not ask for the exact value of *s*; rather, the firms were asked about the percentage of total sales corresponding to innovated (new) products using five intervals: 0, 0–10 percent, 11–30 percent, 31–70 percent, and 71–100 percent. The midpoint value of the interval is used as a proxy for *s*.

A second problem is related to the endogeneity of explanatory variables. As explained by Harrison et al. (2008), endogeneity is derived from nominal sales growth rather than real output growth, as suggested by the theoretical model. However, in the case where it was possible to access real output growth in old and new products, there is another endogeneity problem. Innovations are the result of investment decisions (such as R&D), which have to be decided by firms in advance. These decisions depend on the firm's productivity, which can be thought of as an unobservable of two components: firm's attributes that are mainly constant over time (such as managerial skills or organizational capital) and productivity shocks (which might lead to the firm to reduce labor costs). Given that innovation investments are correlated with firm productivity, then innovation outputs will be also correlated with firm productivity. As firm productivity also shows up in the error term of the labor demand equation, innovation outputs will be endogenous, leading to an identification problem.

In a dynamic setting, lags of the explanatory variables can be used as instruments. Given that Chilean panel data information is available only for a reduced number of firms through all the waves of the innovation surveys, we use an identification strategy based on external instruments. To be valid instruments, these exogenous variables must be highly correlated with innovation decisions but not with employment growth directly. There are several potential instruments that have been considered in the literature: (i) the importance of external sources as the origin of ideas for innovation, (ii) the importance of regulations as objectives for innovation decisions, and (iii) the relevance of obstacles to innovation. All of these variables are assumed to be exogenous and correlated with innovation variables.

The exogeneity of obstacles to innovation based on the firm's perception, however, has been challenged because the more innovative firms may be more aware of these obstacles (Savignac, 2008; Mohnen et al., 2008; Iammarino, et al. 2007; Galia and Legros, 2004). This literature then casts doubts on the validity of these variables as instruments for innovation activities. Because of this concern, we use as instruments the average of these variables for firms located in the same region. The variables at the plant level are defined as the average of the importance for three types of obstacles: economic (technological risk, very long-term return, etc.), workforce-related (low skills, lack of experience, etc.), and other factors (absence of technological or market-related information, innovation is easily imitated, etc.).[7]

The identification strategy used in this paper captures the idea that there are common exogenous factors for firms in a particular region, and it would be less likely to be affected by reverse causality. The assumption herein is that there is a high correlation between obstacles perceived by a firm and others in the same region because they face common and exogenous barriers to innovation. These can be associated with regional differences in credit access, supply of skilled labor and researchers at universities and technological centers, and public funds allocated for innovation.

Benavente and Lauterbach (2008) use as an instrument for innovation the degree of firms' utilization of novel inputs as an origin of innovation ideas. However, these variables are defined only for innovative firms, reducing the number of available observations and generating sample selection problem because the estimation can only be performed for the group of innovative firms. Chilean innovation surveys ask about innovation sources and objectives of the innovation for the group of firms declaring that they are undertaking some type of innovation.

[7] The perception of each obstacle is defined on a five-point scale from 0 (not important) to 4 (highly important). In a previous version of this paper, we used alternatively the average of these three obstacles across firms in the same sector and the average across firms of similar size. The results are similar and available upon request.

Table 6. Naive Regression on the Effect of Innovation on Employment Quantity

Dependent variable: l (Employment growth-yearly)

Sector	**All Manuf**	**All Manuf**	**All Manuf**	**All Manuf**	**Small Manuf**	**Small Manuf**	**Small Manuf**	**Small Manuf**
Regression	**OLS**	**OLS**	**OLS**	**OLS**	**OLS**	**OLS**	**OLS**	**OLS**
Constant	2.109***	2.621***	3.761***	2.566***	2.527***	2.788***	3.463***	2.839***
	(0.642)	(0.65)	(0.601)	(0.603)	(0.958)	(0.943)	(0.9189	(0.9379)
TPP (product or process innovator)	3.144***				4.268***			
	(0.765)				(1.242)			
Product innovator		3.664***				4.206***		
		(0.829)				(1.417)		
Process innovator only		-0.426	-2.319**			0.367	-1.001	
		(1.078)	(0.981)			(2.113)	(2.030)	
TPP red (product and process innovator)				3.736***				4.690***
				(0.741)				(1.397)
Product innovator (only)			-0.254				-2.224	
			(1.845)				(3.207)	
Real sales growth (g1-Π)	0.181***	0.188***	0.176***	0.187***	0.201***	0.203***	0.191***	0.204***
	(0.021)	(0.021)	(0.02)	(0.021)	(0.035)	(0.036)	(0.035)	(0.035)
Time dummies	yes	yes	yes	Yes	yes	yes	yes	yes
2-digit industry dummies	yes	yes	yes	Yes	yes	yes	yes	yes
R-squared	0.1	0.104	0.096	0.104	0.118	0.115	0.105	0.118
Number of firms	2049	2049	2049	2049	652	652	652	652

Notes: (1) Robust standard errors in parentheses, (2) Significance level: *** 1 percent, ** 5 percent, and * 10 percent.

4.2 Econometric Results

Table 6 presents the results for specifications in which, in addition to dummy variables for innovation, a measure of real sales growth of old products is included. The results are similar for both samples. First, the results show that old product sales influence employment growth positively and significantly. Second, they show that the effect of joint process and product innovation is positive and significant, but it seems to be mostly explained by product innovation. Note that most of the regressions show that process innovation by itself does not seem to affect employment growth.

Table 7 presents the results for similar specifications to those in Harrison et al. (2008) for all firms and for small firms only, as well as results dividing the sample between high- and low-tech industries.[8] In all of these regressions, the dependent variable is employment growth minus the real growth of sales due to the unchanged products. The first column includes as explanatory variables a dummy for process innovation and real sales growth due to new products only. In the subsequent columns, we control for foreign ownership, localization, and changes in wages.

We find that the effect of process innovation is negative and significant for all firms, but not for small firms or for firms in low-tech-industries. We also find that sales growth due to product innovation is positively associated with employment growth for all samples under analysis, and that coefficients are very similar across all samples. Then, the results show that there are no relevant differences in this relationship across groups of firms. Finally, these estimations show that foreign ownership and localization are not significant explanatory variables for employment growth, and that wage increases, as expected, generate a displacement effect on employment.

The results of IV estimations are presented in Table 8. As previously explained, the instruments for the sales growth of new products are the importance of three obstacles for innovation averaged across firms located in the same region. These results confirm the existence of a positive and significant effect of the sale of new products on employment growth across all samples analyzed. Note that the coefficient for this variable is much larger than the one in OLS estimations. This finding is consistent with the correction of the downward bias in OLS related to endogeneity and price mismeasurement (Harrison et al., 2008). Also, these IV results show that process innovation does not seem to matter for employment growth in all of the specifications.

[8] We divide the 2-digit industries into two groups by calculating the Innovation Expenditures over turnover for the entire sample. Those sectors below or in the median are low tech, while the rest is classified as high tech.

Table 7. Effect of Innovation on Employment Quantity

Dependent variable: l -(g1-Π)

Sector	All Manuf	All Manuf	All Manuf	Small Manuf	Small Manuf	Small Manuf	High Tech	High Tech	High Tech	Low Tech	Low Tech	Low Tech
Regression	**OLS**	**OLS**	**OLS**	**OLS**	**OLS**	**OLS**	**OLS**	**OLS**	**OLS**	**OLS**	**OLS**	**OLS**
Constant	1.855***	1.997**	3.251***	2.268**	3.136**	5.149***	1.311	1.131	2.755***	2.916**	4.113***	4.591***
	(0.698)	(0.825)	(0.789)	(1.039)	(1.326)	(1.253)	(0.824)	(0.977)	(0.929)	(1.295)	(1.555)	(1.499)
Process innovation only (d)	-2.755**	-2.780**	-2.566**	-3.373	-3.346	-3.406	-2.976**	-2.943**	-2.965**	-2.25	-2.457	-1.858
	(1.274)	(1.275)	(1.181)	(2.716)	(2.717)	(2.414)	(1.50)	(1.492)	(1.352)	(2.362)	(2.406)	(2.309)
Sales growth due to new products (g2)	0.833***	0.833***	0.839***	0.714***	0.706***	0.759***	0.813***	0.813***	0.817***	0.883***	0.879***	0.888***
	(0.034)	(0.034)	(0.031)	(0.083)	(0.084)	(0.074)	(0.039)	)0.039)	(0.036)	(0.064)	(0.064)	(0.061)
Foreign owned (10% or more)		-0.13	-0.409		3.064	2.724		0.061	-0.395		-0.897	-0.721
		(1.231)	(1.191)		(4.309)	(4.323)		(1.347)	(1.269)		(2.874)	(2.977)
Located in the capital (capreg)		-0.275	0.083		-2.318	-2.048		0.395	0.613		-2.208	-1.443
		(0.889)	(0.849)		(1.718)	(1.582)		(1.026)	(0.979)		(1.775)	(1.693)
Growth wage bill per worker			-0.333***			-0.448***			-0.347***			-0.292***
			(0.035)			(0.065)			(0.039)			(0.077)
2-digit industry dummies	yes	yes	yes	yes	yes	Yes	yes	yes	yes	yes	yes	yes
Time dummies	yes	yes	yes	yes	yes	Yes	yes	yes	yes	yes	yes	yes
R-squared	0.27	0.27	0.331	0.159	0.163	0.254	0.268	0.268	0.339	0.279	0.281	0.318
Number of firms	2049	2049	2049	652	652	652	1417	1417	1417	632	632	632

Notes: (1) Robust standard errors in parentheses, (2) Significance level: *** 1 percent, ** 5 percent, and * 10 percent.

Table 8. Effect of Innovation on Employment Quantity

Dependent variable: l -(g1-Π)
List of instrument(s) used: Innovation obstacles (3) averaged by region

Sector	**All Manuf**	**All Manuf**	**All Manuf**	**Small Manuf**	**Small Manuf**	**Small Manuf**	**High Tech**	**High Tech**	**High Tech**	**Low Tech**	**Low Tech**	**Low Tech**
Regression	**IV**	**IV**	**IV**	**IV**	**IV**	**IV**	**IV**	**IV**	**IV**	**IV**	**IV**	**IV**
Constant	-1.989	-2.016	-0.826	-0.61	-2.125	1.237	-2.754	-2.733	-0.332	1.049	1.697	1.608
	(2.794)	(3.0)	(2.909)	(2.711)	(4.701)	(3.843)	(3.507)	(3.368)	(3.056)	(3.189)	(4.206)	(4.234)
Process innovation only (d)	0.297	0.333	0.633	-3.417	-3.38	-3.443	0.028	-0.076	-0.657	-0.551	-0.517	0.581
	(2.495)	(2.572)	(2.517)	(2.698)	(2.921)	(2.621)	(2.951)	(2.835)	(2.589)	(3.398)	(3.787)	(3.86)
Sales growth due to new products (g2)	1.740***	1.751***	1.780***	1.813*	2.141*	1.918*	1.734**	1.695**	1.528**	1.356*	1.403*	1.540*
	(0.633)	(0.653)	(0.638)	(0.927)	(1.205)	(1.052)	(0.765)	(0.728)	(0.664)	(0.744)	(0.846)	(0.858)
Foreign owned (10% or more)		-0.36	-0.653		5.208	4.393		0.362	-0.16		-1.984	-2.066
		(1.449)	(1.416)		(4.699)	(4.179)		(1.620)	(1.483)		(3.332)	(3.353)
Located in the capital (capreg)		0.048	0.425		0.865	0.546		0.237	0.489		-1.399	-0.402
		(1.040)	(1.017)		(3.394)	(3.012)		(1.174)	(1.075)		(2.231)	(2.281)
Growth wage bill per worker			-0.343***			-0.517***			-0.352***			-0.305***
			(0.03)			(0.087)			(0.032)			(0.058)
2-digit industry dummies	yes	yes	Yes	yes	Yes	yes	yes	Yes	yes	yes	yes	yes
Time dummies	yes	Yes	Yes	yes	Yes	yes	yes	Yes	yes	yes	yes	yes
R-squared	0.247	0.247	0.294	0.1401	0.1392	0.2104	0.2458	0.2464	0.3078	0.256	0.2568	0.29
Number of firms	2049	2049	2049	652	652	652	1417	1417	1417	632	632	632
F test, g2	46.210	35.910	32.350	8.100	6.940	6.750	30.250	23.570	21.220	16.530	13.140	11.840
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Davidson-MacKinnon test of exogeneity	2.799	2.709	3.100	1.889	2.235	1.724	2.002	1.982	1.434	0.446	0.429	0.688
P-Value	0.095	0.100	0.079	0.170	0.135	0.190	0.157	0.159	0.231	0.504	0.513	0.407
Sargan (m) 1	2.315	2.549	2.018	0.870	0.738	0.690	0.516	0.490	0.395	3.443	4.442	4.355
Prob. Value	0.314	0.280	0.365	0.647	0.692	0.708	0.773	0.782	0.821	0.179	0.109	0.113
Diff. Sargan (m) 1	2.803	2.716	3.109	1.901	2.255	1.744	2.008	1.991	1.442	0.450	0.435	0.698
Prob. Value	0.094	0.099	0.078	0.168	0.133	0.187	0.157	0.158	0.230	0.502	0.510	0.404

Notes: (1) Robust standard errors in parentheses, (2) Significance level: *** 1 percent, ** 5 percent, and * 10 percent.

Table 9 shows the contribution of innovation to employment growth. In contrast to the findings of Harrison et al. (2008) for European countries, in the Chilean case the net contribution of net product innovation is negative in the case of IV and for the entire sample and also for high- and low-tech industries. Only for small firms do we find a positive contribution of net product innovation. For all samples and IV estimations, the decomposition shows that the contribution of the productivity trend in the production of old products is positive. The results, shown in Table 10, are very similar when this decomposition is carried out for the recovery phase of the cycle.[9]

Table 9. Employment Growth Decomposition

Contributions of innovation to employment growth. Manufacturing. Period 1993–2006.	All Manufacturing		Small firms in Manufacturing		High-tech firms in Manufacturing		Low-tech firms in Manufacturing	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Firms employment growth	-0.181	-0.181	1.447	1.447	-0.127	-0.127	-0.302	-0.302
Productivity trend in production of old products	-0.161	0.904	1.788	0.814	-0.333	0.019	0.219	2.759
Gross effect of process innovation in production of old products	-0.105	-0.132	-0.136	-0.136	-0.105	-0.113	-0.098	-0.183
Output growth of old products contribution	-0.039	-0.039	-0.029	-0.029	0.109	0.109	-0.373	-0.373
Net contribution of product innovation	0.124	-0.914	-0.177	0.798	0.201	-0.144	-0.051	-2.505
Contribution of old products by product innovators	-6.044	-6.044	-3.147	-3.147	-5.980	-5.980	-6.187	-6.187
Contribution of new products by product innovators	6.167	5.129	2.970	3.945	6.181	5.836	6.136	3.682

Source: Authors' elaboration based on Innovation Surveys.

Table 10. Employment Growth Decomposition for the Recovery Phase of the Cycle

Contributions of innovation to employment growth. Manufacturing. Period 2001-2006.	All Manufacturing		Small firms in Manufacturing		High-tech firms in Manufacturing		Low-tech firms in Manufacturing	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Firms employment growth	0.293	0.293	1.801	1.801	-0.019	-0.019	0.980	0.980
Productivity trend in production of old products	0.219	4.594	1.302	1.180	-0.266	4.294	1.284	5.463
Gross effect of process innovation in production of old products	-0.177	-0.321	-0.173	-0.173	-0.157	-0.268	-0.209	-0.439
Output growth of old products contribution	0.407	0.407	0.581	0.581	0.619	0.619	-0.061	-0.061
Net contribution of product innovation	-0.156	-4.387	0.092	0.213	-0.215	-4.663	-0.034	-3.983
Contribution of old products by product innovators	-3.633	-3.633	-2.058	-2.058	-3.817	-3.817	-3.228	-3.228
Contribution of new products by product innovators	3.477	-0.754	2.150	2.272	3.602	-0.846	3.195	-0.754

Source: Authors' elaboration based on Innovation Surveys.

Tables 11 and 12 present some robustness checks. Specifically, we study the exogeneity of d and we test for a structural change in the slope of product innovations. According to the Davidson-MacKinnon test, we reject the exogeneity of process innovation only (d), and we confirm that sales growth due to new products (g2) affects total

[9] This corresponds to the period 2001–2006.

employment positively and significantly (Table 11). In contrast, when the interaction terms are included, most of the parameters are not statistically significant (Table 12). Then, our results reject the idea that there can be differential effects of product innovation depending on whether firms are conducting process innovations.

Table 11. Testing the Endogeneity of d, Dependent Variable: l -(g1-Π)

Sector	All Manuf.	All Manuf.	All Manuf.
Type of Labor	All	Skilled	Unskilled
Regression	IV	IV	IV
Constant	0.377	-6.378	5.873
	(5.647)	(6.786)	(6.452)
Process innovation only (d)	-4.423	14.931	-29.793
	(20.470)	(28.568)	(27.162)
Sales growth due to new products (g2)	1.775***	1.702*	1.540
	(0.640)	(1.029)	(0.978)
Foreign owned (10% or more)	-0.697	2.613	-0.982
	(1.430)	(2.988)	(2.841)
Located in the capital (capreg)	0.166		
	(1.456)		
Growth wage bill per worker	-0.341***		
	(0.031)		
Capital stock growth		-0.031	-0.061**
		(0.033)	(0.031)
Fully foreign owned		-3.000	0.406
		(4.037)	(3.839)
2-digit industry dummies	yes	Yes	yes
Time dummies	yes	Yes	yes
R-sSquared	0.295	0.1219	0.125
Number of firms	2049	1973	1973
F test, g2	33.260	32.120	32.120
p-value	0.000	0.000	0.000
F test, d	7.860	6.460	6.460
p-value	0.000	0.000	0.000
Davidson-MacKinnon test of exogeneity	1.593	0.666	0.867
P-Value	0.204	0.514	0.421
Sargan (m) 1	1.947	0.490	3.421
Prob. Value	0.163	0.484	0.064
Diff. Sargan for d (m) 1	0.062	0.198	1.331
Prob. Value	0.803	0.656	0.249

Notes: Robust standard errors in parentheses, Significance level: *** 1 percent, ** 5 percent, and * 10 percent. List of instrument(s) used: Innovation obstacles (3) averaged by region

Table 12. Testing for a Structural Change, Dependent Variable: l -(g1-Π)

Sector	**All Manuf.**	**All Manuf.**	**All Manuf.**
Type of Labor	**All**	**Skilled**	**Unskilled**
Regression	**IV**	**IV**	**IV**
Constant	4.021***	0.586	3.722***
	(1.186)	(1.406)	(1.319)
Process innovation only (d)	0.501	-0.12	1.337
	(3.792)	(5.066)	(4.752)
Sales growth due to new products (g2)	-0.171	0.427	-0.700
	(1.143)	(1.436)	(1.347)
g2 x product & process innovation	0.914	0.298	1.352
	(1.052)	(1.314)	(1.232)
Foreign owned (10% or more)	-0.637	2.769	-0.498
	(1.267)	(2.691)	(2.524)
Located in the capital (capreg)	-0.462		
	(1.07)		
Growth wage bill per worker	-0.326***		
	(0.027)		
Capital stock growth		-0.009	-0.052**
		(0.023)	(0.022)
Fully foreign owned		-3.331	-0.695
		(3.564)	(3.344)
2-digit industry dummies	Yes	yes	yes
Time dummies	Yes	yes	yes
R-Squared	0.2497	0.1268	0.0801
Number of firms	2049	1973	1973
F test, g2	55.280	52.030	52.030
p-value	0.000	0.000	0.000
F test, g2 x product & process innovation	79.510	75.990	75.990
p-value	0.000	0.000	0.000
Davidson-MacKinnon test of exogeneity	0.810	0.125	0.799
P-Value	0.445	0.883	0.450
Sargan (m) 1	6.723	2.165	4.988
Prob. Value	0.151	0.705	0.289
Diff. Sargan (m) 1	1.627	0.251	1.605
Prob. Value	0.443	0.882	0.448

Robust standard errors in parentheses, Significance level: *** 1 percent, ** 5 percent, and * 10 percent. List of instrument(s) used: Innovation obstacles (3) averaged by region.

5. Innovation and Employment Quality

The section analyzes the impact of innovation on the composition of the workforce. Depending on the skill bias of innovation, its impact may be different for skilled and unskilled workers. Whether innovation is skilled-biased, as several empirical and theoretical studies argue (see, for example, Card and Dinardo, 2002; Acemoglu, 1998),[10] higher innovation could be associated with lower employment growth for unskilled workers and higher employment growth for skilled workers.

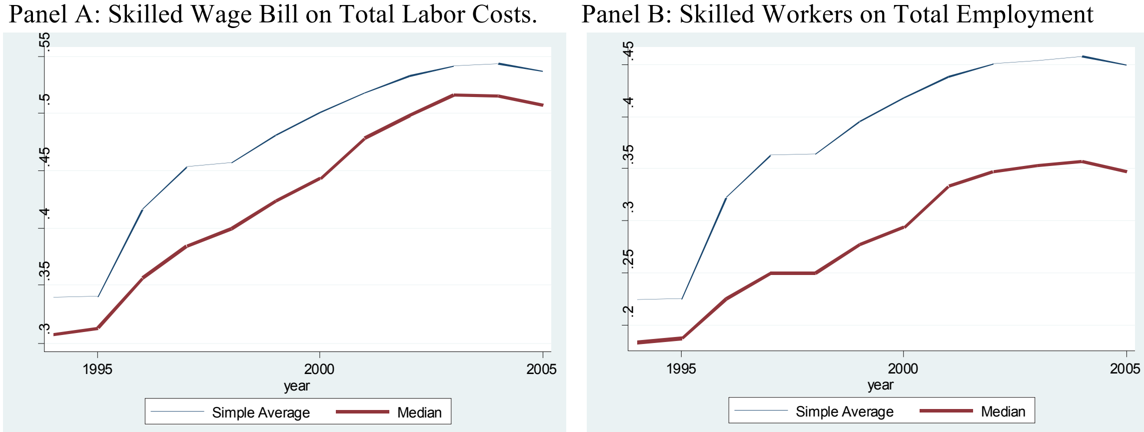
For analyzing the effect of innovation on employment composition, we estimate the following equation:

$$l^{qj} - (g_1 - \Pi) = \alpha_0^{qj} + \alpha_1^{qj} d + \beta_1^{qj} g_2 + \nu_j$$

The dependent variable is employment growth (minus old product real sales growth) for both types of workers: skilled and unskilled. In the basic equation, the explanatory variables are a dummy variable for process innovation (*d*), real sales growth of new products (g_2), capital stock growth, a dummy variable for foreign-owned firms, a dummy variable for full foreign-owned firms, and survey year and 2-digit industries fixed effects.

Figure 1

Panel A: Skilled Wage Bill on Total Labor Costs. Panel B: Skilled Workers on Total Employment



Source: Authors' elaboration based on Annual Survey of Manufactures (ENIA).

The Chilean innovation surveys lack information the skill level of workers. However, each of these surveys is matched with the Annual Survey of Manufacturers. Specifically, we use the broad classification of skilled and unskilled workers as white-collar and blue-collar workers directly from the Annual Survey of Manufacturers. To indicate the evolution

[10] For the case of Chile, see Gallego (2011).

of skill composition in Chilean industry, we show the evolution of the skilled wage bill as a proportion of total labor costs (Figure 1A) and skilled workers as a proportion of total employment (Figure 1B) for the period 1994–2005. In both cases, the evidence suggests a process of skill upgrading in Chilean manufacturing industries.

Table 13. Descriptive Statistics for Employment Composition, All Manufacturing 1993–2006

Share of skilled labor (at the beginning of each survey)	Mean	Median	Standard deviation	Minimum	Maximum
All firms	0.35	0.29	0.22	0.02	0.99
Noninnovators (no process or product innovations)	0.36	0.29	0.24	0.02	0.98
Process only innovators (non-product innovators)	0.35	0.28	0.25	0.04	0.98
Organizational change innovator (non-product innovators)	0.35	0.29	0.24	0.02	0.96
Product innovators	0.34	0.29	0.21	0.02	0.99
Employment (total) growth (%)					
All firms	-0.18	0.00	14.65	-67.43	62.14
Noninnovators (no process or product innovations)	0.80	0.00	14.59	-66.79	58.32
Process only innovators (non-product innovators)	2.12	3.62	14.02	-41.01	34.01
Organizational change innovator (non-product innovators)	-1.96	-0.65	17.79	-53.39	62.14
Product innovators	-0.52	-0.39	13.89	-67.43	58.59
Skilled labor growth (%)					
All firms	0.27	0.00	25.05	-110.29	97.30
Noninnovators (no process or product innovations)	0.48	0.00	24.97	-107.00	95.85
Process only innovators (non-product innovators)	2.62	0.00	20.71	-70.99	86.14
Organizational change innovator (non-product innovators)	-0.29	0.00	27.56	-102.71	97.30
Product innovators	0.09	0.00	24.82	-110.29	95.38
Unskilled labor growth (%)					
All firms	-0.62	0.00	23.41	-104.17	107.97
Noninnovators (no process or product innovations)	0.94	0.00	23.42	-97.30	103.97
Process only innovators (non-product innovators)	1.11	2.97	20.12	-77.53	53.75
Organizational change innovator (non-product innovators)	-2.72	-0.28	27.71	-104.17	98.31
Product innovators	-1.19	-0.24	22.54	-100.41	107.97

Sources: Authors' elaboration based on Innovation Surveys.

Tables 13 and 14 present descriptive statistics for the entire sample and small firms. For all firms, the average and median share of skilled labor is 35 percent and 29 percent, respectively, and very similar across types of innovators. These figures are also similar to those in the sample of small firms, with an average and median of 36 percent and 29 percent, respectively. For the entire sample, the average increase in skilled labor was 0.3 percent and -0.6 percent for unskilled labor.

There are important differences across firms. The highest growth in skilled and unskilled labor was experienced by process only innovators (non-product innovators) and the lowest for organizational change innovators (non-product innovators). In the case of small firms, the average growth in unskilled labor (2.3 percent) was higher than the average growth in skilled labor (0.1 percent), and similar to the entire sample. The highest expansion in both types of workers corresponded to process only innovators (non-product innovators).

Table 14. Descriptive Statistics for Employment Composition: All Manufacturing 1993–2006

Share of skilled labor (at the beginning of each survey)	Mean	Median	Standard deviation	Minimum	Maximum
All firms	0.36	0.30	0.23	0.03	0.98
Noninnovators (no process or product innovations)	0.38	0.31	0.24	0.03	0.98
Process only innovators (non-product innovators)	0.34	0.26	0.26	0.04	0.94
Organizational change innovator (non-product innovators)	0.35	0.29	0.23	0.06	0.96
Product innovators	0.34	0.27	0.21	0.05	0.96
Employment (total) growth (%)					
All firms	1.45	0.00	15.22	-53.39	58.32
Noninnovators (no process or product innovations)	1.49	0.00	14.62	-49.04	58.32
Process only innovators (non-product innovators)	4.54	3.79	11.05	-13.88	34.01
Organizational change innovator (non-product innovators)	-1.08	0.00	19.98	-53.39	46.12
Product innovators	1.83	0.00	14.96	-44.12	52.23
Skilled labor growth (%)					
All firms	0.14	0.00	25.01	-102.71	97.30
Noninnovators (no process or product innovations)	-0.24	0.00	23.86	-93.59	95.85
Process only innovators (non-product innovators)	10.19	0.00	24.17	-20.27	86.14
Organizational change innovator (non-product innovators)	-2.02	0.00	30.51	-102.71	97.30
Product innovators	0.38	0.00	25.15	-85.24	78.43
Unskilled labor growth (%)					
All firms	2.27	0.00	23.81	-97.30	107.97
Noninnovators (no process or product innovations)	2.26	0.00	23.87	-97.30	103.97
Process only innovators (non-product innovators)	3.34	1.85	15.11	-21.14	40.55
Organizational change innovator (non-product innovators)	-1.91	0.00	25.85	-73.32	53.04
Product innovators	3.61	0.00	23.87	-69.31	107.97

Sources: Authors' elaboration based on Innovation Surveys.

The concerns about endogeneity analyzed in the employment equation are also relevant for this employment quality regression. The identification strategy used is the same as before. In the absence of panel data, we use external instrumental variables. These are the ones explained in previous section under the assumption that there are exogenous variables explaining innovation decisions that are not correlated with the error term of the equation. These are the average region-specific variables related to three types of obstacles for innovation.

Table 15. Effect of Innovation on Employment Quality (OLS Approach)

Sector Regression	All Skilled OLS	All Unskilled OLS	Small Skilled OLS	Small Unskilled OLS	H-T Skilled OLS	H-T Unskilled OLS	L-T Skilled OLS	L-T Unskilled OLS
Constant	0.045	2.823***	-0.079	3.163**	-0.478	3.106**	1.350	2.219
	(1.083)	(1.020)	(1.523)	(1.453)	(1.269)	(1.280)	(2.051)	(1.697)
Process innovation only (d)	-0.894	-3.388*	0.52	-5.836*	0.702	-5.015**	-4.558	-0.157
	(1.837)	(1.785)	(3.693)	(3.328)	(2.190)	(2.218)	(3.254)	(2.977)
Sales growth due to new products (g2)	0.841***	0.814***	0.793***	0.695***	0.872***	0.782***	0.783***	0.885***
	(0.052)	(0.048)	(0.104)	(0.109)	(0.061)	(0.06)	(0.101)	(0.077)
Capital stock growth	-0.01	-0.050*	-0.063	-0.046	-0.002	-0.045	-0.026	-0.059
	(0.029)	(0.026)	(0.05)	(0.034)	(0.037)	(0.034)	(0.042)	(0.039)
Foreign owned (10% or more)	2.854	0.113	4.147	0.972	2.571	-0.72	3.794	1.838
	(2.769)	(2.606)	(8.723)	(6.402)	(3.304)	(3.188)	(5.142)	(4.563)
Fully foreign owned	-3.342	-1.053	4.908	8.828	-1.587	0.264	-13.448**	-5.409
	(3.478)	(3.448)	(10.788)	(11.436)	(4.026)	(4.074)	(6.750)	(6.128)
2-digit industry dummies	Yes	yes	yes	yes	yes	yes	Yes	yes
Time dummies	Yes	yes	yes	yes	yes	yes	Yes	yes
R-squared	0.144	0.163	0.116	0.112	0.143	0.151	0.159	0.198
Number of firms	1973	1973	625	625	1363	1363	610	610

Notes: (1) Robust standard errors in parentheses, (2) Significance level: *** 1 percent, ** 5 percent, and * 10 percent. (3) H-T and L-T means High and Low-Technology Industries respectively.

The OLS estimations for all and small firms, and high-tech and low-tech industries are presented in Table 15. We find that process innovation has a negative and significant effect on unskilled employment growth except in low-tech industries. In contrast, our findings show that product innovation—measured by sales growth due to new product—increased both types of employment, and the parameter is practically the same for skilled and unskilled workers. This is valid across all the samples of firms. The IV estimations are shown in Table 16 and they are not satisfactory. Most of the coefficients turn out to be not significant.

Tables 17 through 20 present the decomposition of the effect of innovation-related variables on employment growth for both types of workers, across types of firms, and across industries. Given the unsatisfactory results for IV estimations, we discuss the results from OLS regressions. These results show that for skilled workers, the net contribution of product innovation is positive and large for all firms and those in high-tech industries. By contrast, the contribution for small firms, although positive, is of low magnitude, and it is negative for firms in low-tech industries. The contribution of process innovation in old products to employment growth is generally negative, with the exception of firms in high-tech industries.

Table 16. Effect of Innovation on Employment Quality (IV Approach).

Sector Regression	All Skilled IV	All Unskilled IV	Small Skilled IV	Small Unskilled IV	H-T Skilled IV	H-T Unskilled IV	L-T Skilled IV	L-T Unskilled IV
Constant	-4.072	0.763	-1.299	1.025	-5.059	3.488	-1.782	-0.923
	(4.414)	(3.778)	(3.555)	(3.307)	(5.654)	(4.794)	(5.10)	(4.441)
Process innovation only (d)	2.296	-1.792	0.493	-5.885*	3.983	-5.288	-1.776	2.635
	(3.804)	(3.255)	(3.442)	(3.202)	(4.551)	(3.859)	(5.306)	(4.620)
Sales growth due to new products (g2)	1.810*	1.299	1.237	1.472	1.906	0.696	1.581	1.686
	(1.003)	(0.858)	(1.160)	(1.080)	(1.236)	(1.048)	(1.196)	(1.041)
Capital stock growth	-0.031	-0.061**	-0.064*	-0.048	-0.027	-0.043	-0.04	-0.073*
	(0.033)	(0.028)	(0.035)	(0.033)	(0.043)	(0.036)	(0.045)	(0.039)
Foreign owned (10% or more)	2.254	-0.187	4.845	2.194	2.424	-0.708	2.533	0.574
	(2.888)	(2.472)	(6.663)	(6.199)	(3.364)	(2.852)	(5.525)	(4.810)
Fully foreign owned	-2.526	-0.645	5.096	9.158	-0.655	0.186	-14.406	-6.37
	(3.909)	(3.345)	(10.418)	(9.692)	(4.471)	(3.791)	(8.792)	(7.655)
2-digit industry dummies	Yes	yes	yes	yes	yes	yes	Yes	yes
Time dummies	Yes	yes	yes	yes	yes	yes	Yes	yes
R-Squared	0.130	0.149	0.097	0.098	0.134	0.145	0.135	0.170
Number of firms	1973	1973	625	625	1363	1363	610	610
F test, g2	31.130	31.130	5.940	5.940	20.400	20.400	11.150	11.150
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Davidson-MacKinnon test of exogeneity	1.101	0.337	0.151	0.577	0.844	0.007	0.500	0.691
p-Value	0.294	0.562	0.698	0.448	0.359	0.934	0.480	0.406
Sargan (m) 1	0.685	5.523	1.466	0.559	0.596	1.772	0.574	6.478
Prob. Value	0.710	0.063	0.481	0.756	0.742	0.412	0.750	0.039
Diff. Sargan (m) 1	1.105	0.339	0.153	0.585	0.849	0.007	0.507	0.701
Prob. Value	0.293	0.561	0.695	0.445	0.357	0.934	0.476	0.403

Notes: (1) Robust standard errors in parentheses, (2) Significance level: *** 1 percent, ** 5 percent, and * 10 percent, (3) H-T and L-T means High and Low-Technology Industries respectively.

For unskilled workers, we find that the net contribution of product innovation is generally negative. Thus, these results are consistent with the idea that product innovation is skill-biased in the Chilean case. These differences in the contribution of product innovation to employment growth across types of workers are valid for all the samples and for the entire period under analysis, but they do not hold for the shorter period 2001–2006 (Tables 19 and 20).

Table 17. Employment Growth Decomposition for Skilled Labor

Contributions of innovation to employment growth. Manufacturing. Period 1993–2006.	All Manufacturing		Small firms in Manufacturing		High-tech firms in Manufacturing		Low-tech firms in Manufacturing	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Firms employment growth	0.267	0.267	0.142	0.142	0.175	0.175	0.472	0.472
Productivity trend in production of old products	0.157	-0.411	0.185	-0.434	-0.410	-0.676	1.451	0.456
Gross effect of process innovation in production of old products	-0.058	-0.044	-0.030	-0.030	0.022	0.028	-0.282	-0.249
Output growth of old products contribution	-0.039	-0.039	-0.029	-0.029	0.109	0.109	-0.373	-0.373
Net contribution of product innovation	0.207	0.760	0.016	0.635	0.454	0.714	-0.324	0.637
Contribution of old products by product innovators	-6.044	-6.044	-3.147	-3.147	-5.980	-5.980	-6.187	-6.187
Contribution of new products by product innovators	6.251	6.804	3.163	3.782	6.433	6.694	5.863	6.824

Source: Authors' elaboration based on Innovation Surveys.

Table 18. Employment Growth Decomposition for Unskilled Labor

Contributions of innovation to employment growth. Manufacturing. Period 1993–2006.	All Manufacturing		Small firms in Manufacturing		High-tech firms in Manufacturing		Low-tech firms in Manufacturing	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Firms employment growth	-0.624	-0.624	2.275	2.275	-0.507	-0.507	-0.887	-0.887
Productivity trend in production of old products	-0.260	1.560	2.735	1.085	-0.184	1.547	-0.451	1.775
Gross effect of process innovation in production of old products	-0.130	-0.177	-0.210	-0.211	-0.174	-0.213	0.002	-0.072
Output growth of old products contribution	-0.039	-0.039	-0.029	-0.029	0.109	0.109	-0.373	-0.373
Net contribution of product innovation	-0.194	-1.967	-0.222	1.429	-0.259	-1.951	-0.065	-2.217
Contribution of old products by product innovators	-6.044	-6.044	-3.147	-3.147	-5.980	-5.980	-6.187	-6.187
Contribution of new products by product innovators	5.849	4.076	2.925	4.576	5.721	4.028	6.122	3.970

Source: Authors' elaboration based on Innovation Surveys.

Table 19. Employment Growth Decomposition for Skilled Labor for Recovering Phase of Cycle

Contributions of innovation to employment growth. Manufacturing. Period 2001–2006.	All Manufacturing		Small firms in Manufacturing		High-tech firms in Manufacturing		Low-tech firms in Manufacturing	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Firms employment growth	0.585	0.585	0.606	0.606	0.590	0.590	0.574	0.574
Productivity trend in production of old products	0.492	1.777	-0.070	-0.623	-0.028	0.802	1.860	2.443
Gross effect of process innovation in production of old products	-0.176	-0.218	-0.028	-0.029	-0.044	-0.064	-0.611	-0.643
Output growth of old products contribution	0.407	0.407	0.581	0.581	0.619	0.619	-0.061	-0.061
Net contribution of product innovation	-0.138	-1.381	0.123	0.678	0.042	-0.767	-0.614	-1.165
Contribution of old products by product innovators	-3.633	-3.633	-2.058	-2.058	-3.817	-3.817	-3.228	-3.228
Contribution of new products by product innovators	3.495	2.252	2.182	2.736	3.859	3.050	2.614	2.064

Source: Authors' elaboration based on Innovation Surveys.

Table 20. Employment Growth Decomposition for Unskilled Labor for Recovering Phase of Cycle

Contributions of innovation to employment growth. Manufacturing. Period 2001–2006.	All Manufacturing		Small firms in Manufacturing		High-tech firms in Manufacturing		Low-tech firms in Manufacturing	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Firms employment growth	-0.277	-0.277	2.423	2.423	-0.462	-0.462	0.131	0.131
Productivity trend in production of old products	-0.350	4.025	1.923	1.802	-0.709	3.851	0.434	4.614
Gross effect of process innovation in production of old products	-0.177	-0.321	-0.173	-0.173	-0.157	-0.268	-0.209	-0.439
Output growth of old products contribution	0.407	0.407	0.581	0.581	0.619	0.619	-0.061	-0.061
Net contribution of product innovation	-0.156	-4.387	0.092	0.213	-0.215	-4.663	-0.034	-3.983
Contribution of old products by product innovators	-3.633	-3.633	-2.058	-2.058	-3.817	-3.817	-3.228	-3.228
Contribution of new products by product innovators	3.477	-0.754	2.150	2.272	3.602	-0.846	3.195	-0.754

Source: Authors' elaboration based on Innovation Surveys.

6. Innovation Strategies and Employment

In this section, we analyze the effect of innovation strategies on employment. To do that, we use questions from the Chilean Innovation Survey that looked at the types of innovation strategies conducted by the firms.[11] Specifically, we define two dummy variables for internal (make) and external (buy) innovation, using the response to the questions asking whether during the last two years the firm undertook the following innovative activities:

1. Carried out R&D within the firm
2. Carried out R&D outside the firm
3. Purchased external knowledge (patents, licenses, know-how)

"Make only" is a dummy variable taking the value 1 if the response to question 1 is affirmative and responses to questions 2 and 3 are negative; and 0 otherwise. "Buy only" is a dummy variable taking the value 1 if the response to questions 2 and 3 is affirmative and response to question 1 is negative; and 0 otherwise. Finally, to look at potential reinforcing effects of both activities, we also included a dummy variable for firms claiming to carry out both make and buy innovations. In such a case, make and buy is 1 if response to question 1 is affirmative and any of responses to other questions is positive; otherwise, it is 0.

[11] Unfortunately, given the requirements for defining these variables, we have only one available survey where this question was introduced. Therefore, in this section, we report only the analysis for the 2007 innovation survey.

Table 21. Descriptive Statistics for Strategies. All Manufacturing 2004–2006

Share of firms pursuing each type of strategy by type of firm (%)	Buy Only	Make Only	Make and Buy
All firms	4.43	12.81	9.22
Noninnovators (no process or product innovations)	1.07	2.78	1.07
Process only innovators (non-product innovators)	7.41	12.96	12.96
Organizational change innovator (non-product innovators)	7.14	13.49	11.90
Product innovators	10.11	37.23	26.60

Source: Authors' elaboration based on Innovation Surveys.

Tables 21 and 22 present descriptive statistics for the entire sample and for small firms, respectively, and for the three different innovation strategies: buy only, make only, and make and buy. For both samples, the most prevalent strategy is "make only", representing 12.8 percent for all firms and 7.1 percent in small firms. This is valid across the different types of firms. Notably, product innovators are more likely to use the three strategies compared with the rest of the firms. In both samples, about 30 percent of product innovators follow a make only strategy. The prevalence of these strategies, as expected, is very low for noninnovators (no process or product innovations).

Table 22. Descriptive Statistics for Strategies. Small Firms in Manufacturing 2004–2006

Share of firms pursuing each type of strategy by type of firm (%)	Buy Only	Make Only	Make and Buy
All firms	1.96	7.11	2.45
Noninnovators (no process or product innovations)	0.33	1.32	0.66
Process only innovators (non-product innovators)	0.00	13.33	0.00
Organizational change innovator (non-product innovators)	8.11	13.51	2.70
Product innovators	7.41	33.33	12.96

Source: Authors' elaboration based on Innovation Surveys

Table 23 presents the OLS regression for total employment growth for all and small firms, and for high- and low-tech industries. The main result of these estimations is that in-house innovation (make only) is positive and significantly associated with employment growth. In contrast, the buy only strategy and both strategies together are not found to be significantly associated with employment. This result holds across the different samples, suggesting that there are no relevant differences by firm size or technological intensity of industries

Table 23. Innovation Strategies

Sector Regression	All Manuf OLS	All Manuf OLS	Small Manuf OLS	Small Manuf OLS	High Tech OLS	High Tech OLS	Low Tech OLS	Low Tech OLS
Constant	3.695***	4.466***	3.122***	4.233***	3.570***	4.221***	3.971***	5.070***
	(0.757)	(1.095)	(1.101)	(1.52)	(0.904)	(1.353)	(1.374)	(1.881)
Make (dummy)	5.485***	5.923***	6.039	6.672*	4.033*	4.264*	10.225**	10.042**
	(2.067)	(2.112)	(3.749)	(3.862)	(2.303)	(2.377)	(4.52)	(4.402)
Buy (dummy)	1.724	1.817	4.48	4.351	-1.741	-1.796	7.597	7.327
	(3.389)	(3.415)	(11.485)	(11.381)	(3.666)	(3.685)	(6.431)	(6.431)
Make & Buy (dummy)		2.287		4.804		0.433		6.771
		(2.238)		(5.588)		(2.236)		(4.754)
Foreign Ownsership (dummy)		0.596		3.972		-2.202		11.059*
		(2.18)		(6.302)		(2.025)		(6.559)
Located in the capital region (dummy)		-2.460*		-3.417		-1.004		-5.135*
		(1.491)		(2.25)		(1.748)		(2.825)
2-digit industry dummies	Yes	yes	yes	yes	yes	yes	yes	yes
R-squared	0.027	0.031	0.034	0.042	0.013	0.015	0.053	0.083
Number of firms	835	835	408	408	550	550	285	285

Notes: (1) Robust standard errors in parentheses, (2) Significance level: *** 1 percent, ** 5 percent, and * 10 percent..

The estimated impact of innovation strategies on skilled and unskilled workers is shown in Table 24 for all and small firms and for high- and low-tech industries. For the whole sample of firms, we find a positive and significant effect of in-house innovation over employment growth of both types of workers. In addition, there is some evidence of reinforcing effects of both strategies in the case of skilled workers. For the sample of small firms, we find some differences compared to the whole sample. The make only strategy is positive and significant for skilled workers only, and we do not find evidence of reinforcing effects of both strategies.

In the case of high- and low-tech industries, we find that the estimated model does not reflect the behavior of firms in high-tech industries. Most of the parameters are not significant for that sample. However, the results for low-tech industries show that in-house innovation positively and significantly affects employment growth for unskilled workers.

In sum, our results show that the external innovation strategy does not affect overall employment growth either for skilled or unskilled workers. This evidence is robust across firm size and technological intensity. In contrast, make only innovation positively affects employment growth, but there are significant differences across types of worker, firm size, and technological intensity.

Table 24. Innovation Strategies for Different Types of Labor

Sector	All Skilled	All Skilled	All Unskilled	All Unskilled	Small Skilled	Small Skilled	Small Unskilled	Small Unskilled	H-T Skilled	H-T Skilled	H-T Unskilled	H-T Unskilled	L-T Skilled	L-T Skilled	L-T Unskilled	L-T Unskilled
Regression	**OLS**	**OLS**	**OLS**	**OLS**	**OLS**	**OLS**	**OLS**	**OLS**	**OLS**	**OLS**	**OLS**	**OLS**	**OLS**	**OLS**	**OLS**	**OLS**
Constant	3.005***	3.742**	3.955***	5.119***	1.547	2.45	3.436**	5.162***	3.386***	3.528*	4.423***	5.667***	2.318	4.421	3.096***	4.06
	(1.10)	(1.543)	(1.072)	(1.529)	(1.505)	(2.054)	(1.493)	(1.994)	(1.296)	(1.862)	(1.327)	(1.872)	(2.037)	(2.784)	(1.826)	(2.639)
Make (dummy)	4.823	5.811*	5.669*	6.030*	14.198**	15.055***	1.289	2.168	2.608	3.375	3.554	3.955	12.173**	12.710**	12.719**	11.875**
	(3.042)	(3.090)	(3.106)	(3.142)	(5.680)	(5.743)	(5.445)	(5.601)	(3.547)	(3.63)	(3.635)	(3.682)	(5.594)	(5.647)	(5.623)	(5.61)
Buy (dummy)	-0.774	-0.378	2.289	2.225	-9.696	-9.595	11.64	11.427	-4.363	-4.021	-0.658	-0.829	5.357	5.91	7.344	6.379
	(3.690)	(3.661)	(4.762)	(4.834)	(9.898)	(9.697)	(12.081)	(11.913)	(4.608)	(4.625)	(5.905)	(6.014)	(5.896)	(5.855)	(7.887)	(7.732)
Make & Buy (dummy)		6.875*		1.268		10.415		3.77		5.154		0.597		10.378		4.137
		(3.906)		(3.593)		(6.941)		(6.064)		(3.714)		(4.255)		(8.556)		(6.624)
Foreign ownership (dummy)		2.981		0.992		5.97		7.22		1.562		-2.899		7.632		15.205*
		(3.304)		(3.414)		(8.066)		(6.103)		(3.436)		(3.674)		(8.836)		(7.819)
Located in the capital region (dummy)		-4.066*		-3.179		-3.529		-5.201*		-2.118		-2.232		-7.817*		-4.631
		(2.267)		(2.125)		(3.148)		(2.988)		(2.688)		(2.642)		(4.209)		(3.572)
2-digit industry dummies	yes	yes	yes	yes	yes	yes	yes	yes	Yes	yes	Yes	yes	yes	yes	yes	yes
R-squared	0.023	0.032	0.027	0.030	0.069	0.078	0.038	0.049	0.006	0.01	0.013	0.016	0.054	0.076	0.059	0.079
Number of firms	835	835	835	835	408	408	408	408	550	550	550	550	285	285	285	285

Notes: (1) Robust standard errors in parentheses, (2) Significance level: *** 1 percent, ** 5 percent, and * 10 percent.

7. Conclusions

In this paper we have drawn on several sources of information to shed light on the relationship between innovation and employment growth. This quantitative approach has been complemented by case studies and interviews of researchers and policymakers. The overarching conclusions are that process innovation is generally found not to be a relevant determinant of employment growth in Chilean manufacturing plants, and that product innovation is frequently positively associated with an expansion of employment. We find that this evidence is similar for small firms.

Our results are consistent with previous empirical evidence showing ambiguous expected effects of process innovation and, generally, positive effects of product innovation. This is also consistent with our discussions with researchers, policymakers, and firm managers. Most of them agree with the expected differences in the impact of both types of innovation. Moreover, the potential negative effect of process innovation does not seem to be an important consideration when undertaking innovation within the firm or implementing public innovation policies.

We also explored the impact of innovation on the composition of the workforce. As suggested by the theoretical and empirical literature, depending on the skill bias of innovation, its impact may be different for skilled and unskilled workers. We find that process innovation, in general, has a negative and significant effect on unskilled employment growth, with the exception of low-tech industries. By contrast, our findings show that product innovation increases both types of employment growth. The decomposition of employment growth in its main components reveals some interesting results. For skilled workers, the net contribution of product innovation is positive and large for all firms and those in high-tech industries. In the case of unskilled workers, we find that the net contribution of product innovation is generally negative. Thus, these results suggest some evidence consistent with the idea that product innovation would be skill biased in the Chilean case. However, these results, based on OLS regressions, should be viewed with caution, given that they are not confirmed by estimations with instrumental variables.

Finally, using information for one innovation survey only, we analyzed the effect of two different innovation strategies on employment growth and skill composition. Our results show that in-house innovation (make only) is positive and significantly associated with employment growth. In contrast, buy only and make-or-buy strategies are not found to be significantly associated with employment growth. These findings hold across all samples, suggesting that there are no relevant differences with respect to firm size or technological intensity.

The effect of innovation strategies on skill composition is more mixed. In general, external innovation does not affect employment growth of skilled and unskilled workers. This evidence is robust across firm size and technological intensity of industries. In contrast, the effect of "in house" innovation is different across types of workers, firm size, and technological intensity. We found that R&D within firms increases employment growth of skilled workers in small firms, but it has no impact on unskilled workers in these firms. In addition, any of these strategies affects employment growth of skilled workers in high-tech industries, but "in house" R&D increases employment growth for both types of workers in low-tech industries. These mixed results may be attributable to the broad categories that are used in the estimations. There is a lot of heterogeneity within both categories affecting the chances of finding reasonable results. It reveals that more disaggregation is potentially required to investigate the negative effects of technological change on unskilled workers.

These findings have some relevant policy implications. First, given that product innovation and process innovations have similar effects on large and small firms, public policy would not need to be concerned with the effects of innovation on employment for small firms. In fact, a first order issue is how to make small firms innovate more and take advantage of the positive effects of innovation on employment growth.

Second, our finding of a negative effect of innovation on unskilled workers calls for further analysis. Given that innovation can displace less skilled workers, a closer interaction between innovation and training policies in Chile might be required. As far as we know as a result of our interviews with managers and policymakers, there are no specific public programs dealing with this issue. Although we do not address labor marker regulations specifically, this evidence may be consistent with the idea that raising the cost of hiring unskilled workers, as a result of minimum wages increases, may bias innovation against less qualified workers. This is an issue that need be addressed empirically, but policymakers need to be aware of this potential collateral issue related to labor regulations.

Finally, the differences in the effect of in-house R&D on low- and high-tech industries can have some implication for the recent reformulation of the R&D tax credit. Whenever this subsidy incentivizes internal R&D, there may be differential effects on employment growth for high- and low-tech industries. According to our results, in-house R&D tends to increase employment for both types of workers in low-tech manufacturing industries. The effect on high-tech industries is an issue deserving more attention by policymakers in Chile.

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Appendix 1
Case Studies of Chilean Firms

Case 1: Cuerotexsa

Cuerotexsa is a small business devoted to manufacturing and marketing synthetic leather products. It was founded in 1973 to meet the needs of new markets, especially in Latin-America. Since its founding, the company has been dedicated to developing a service orientation, which has enabled it to survive in a highly competitive market, especially in the face of competition from China.

The firm's main export market is the Argentinean women's shoe market, and it has been forced to innovate constantly in order to compete. According to the general manager, Cuerotexsa has had to develop several innovations in its productive process in order to increase the efficiency of production. The implementation of process innovation has been a response to requirements to reduce pollutants emission and adjust to environmental regulations, increase production speed, and reduce the number of days that the factory has to close.

The main source of innovation in Cuerotexsa has been external, the result of acquisition of new machinery for improving its productive process. There is little "in-house" innovation. However, the company has developed its own innovation in the production of synthetic leather aimed at the Argentinean women's shoe market, because of the need to adjust to new trends in the fashion industry.

Carlos Jofré, manager of Cuerotexsa, pointed out that the company has undergone a cultural shift through significant changes in the workforce. During the last three years, employment has maintained relatively stable, increasing slightly from 41 workers in 2007 to 45 in 2010. He underscored the close relationship between the type of innovation and employment generation, not with innovation itself. Jofré believes that product innovation is more closely associated with increases in employment. In contrast, process innovation, whose aim is to improve efficiency, can have a negative effect on employment.

Cuerotexsa considers that obstacles to innovation are more related to a lack of resources than to internal characteristics of the business. Both the workers and management are aware that in order to survive and keep growing, innovation efforts must continue.

An analysis of the government's innovation policies points shows that they have been implemented with the correct and most relevant objectives, but that there is some positive bias toward firms that have experience in the application of public instruments. The absence of clear and accessible information is one of the biggest obstacles that the small and medium sized enterprises must overcome in order to access the government's pro-innovation policies. Finally, this firm highlights the existence of high transaction costs compared with the benefits that public programs could bring to firms.

Case 2: SlipNaxos

SlipNaxos Chile S.A. was founded in 1997 from the cooperation between Chilean entrepreneurs and the Swedish firm NaxoFlex AB. It focuses on providing solutions in the abrasive and adhesive area to the timber and the metalworking industries. SlipNaxos is a small enterprise employing 18 workers. It specializes in the commercialization of abrasive and adhesive products. In the last three years, employment has grown by about 30 percent, explained by the import of new products and the increase in domestic production due to improvements in the manufacturing process of abrasive products.

The company considers itself open to new possibilities and innovation. Although it believes that the lack of resources for small companies decreases or delays innovation SlipNaxos has been able to develop in-house innovation for marketing its products. In contrast, most of the product innovation comes from its international partners.

Christian Enriquez, SlipNaxos' manager, points out that public funds aimed at encouraging innovation are more targeted to the creation of new technologies than to their adoption. This is only one of the many obstacles that small and medium sized companies have to overcome in order to access these funds. In addition, the lack of information and the scarce correlation between expected gains and the cost are issues that Enriquez sees as fundamental problems to be resolved.

Enriquez also points out that there is a relationship between the type of innovation and employment growth. He believes that a product innovation should bring about an increase in employment, as occurred in this firm with the import of new products of the American brand "Franklin Titebon". In the case of process innovation, he considers that it should generate a decrease in employment. In his own experience, this has not been the case.

SlipNaxos has been able to increase workers' training and maintain the same number of employees.

Case 3: CMPC Tissue

With factories in Chile, Argentina, Peru, and Uruguay, CMPC Tissue manufactures and markets tissue products such as toilet paper, kitchen paper towels, and tissue paper based on the use of cellulose and recycled paper. CMPC Tissue is considered the leader in the Chilean, Argentinean, and Uruguayan tissue market, and in Peru its market share is growing constantly and currently is in second place. In these countries, CMPC also manufactures specialized products for enterprises, institutions, and external clients with a marketing structure especially designed for these costumers.

Eduardo Lucachewski, manager of the plant located in Santiago, said that the company is in a constant process of innovation in both products and processes. He asserts that most innovations in this firm have been the result of strategic alliances with various machinery producers for the paper industry. These partners conduct various kinds of research and are financed by CMPC. In this sense, this company produces external innovation, but with a high degree of involvement.

The manager remarked that innovation in this company has not greatly affected the level of employment. However, he thinks that innovation generates two types of effects: (i) niche product innovation generates an increase in employment because it increases the demand for goods produced by the firm, and (ii) process innovation, by contrast, results in substitution between the use of machinery and labor, decreasing the demand for workers. However, he noted that in the last three years, the product innovation effect has predominated, and CMPC Tissue has experienced a slight increase in the number of employees.

Lucachewski also pointed out the differences between in-house and external innovation. He believes that in-house innovation would probably generate a substitution effect between unskilled and skilled labor (researchers) and a productivity effect that will slow down employment, versus external innovation, which produces only a decrease in unskilled labor.

Finally, the manager evaluated the government's innovation policies, concluding that the biggest weakness in Chilean innovation policy is the lack of incentives and specific measures for facilitating worker training. He proposed the creation of training programs tailored to the needs of each company, according to the number of workers and the time availability of the company.

Case 4: CALPER

CALPER was founded in 1990 to meet a latent demand in the work shoes market. This firm is specialized in the development, manufacturing, and commercialization of occupational shoes, using Chilean leather and high-quality inputs imported from Brazil and Mexico. This is a dynamic firm that has been able to compete successfully with imports from low-wage countries such as China. Since 2007, it has experienced an employment growth of about 90 percent, explained, according to the marketing manager, by an increase in sales and product innovation.

Gonzalo Perez Urquiaga, marketing manager of the firm, pointed out that Calper is a firm that constantly innovates in the areas of marketing, product, management, and process. The main reason behind these broad innovation efforts is increasing competition from China's low-cost products. In this case, innovation is considered a condition for the firm's survival.

This company is an interesting example of in-house innovation. It had to develop and manufacture its own machinery for producing shoes, given that the market for this type of machinery lacks suitable products for the firm's needs. Then, to meet the demands of the market and to provide better products, Calper was forced to develop and innovate in-house.

Regarding the employment effects of innovation, Perez considers them to be broadly positive. However, he thinks that successful experiences need the joint collaboration of workers and managers; otherwise, innovation efforts are destined to failure.

The expressed a high degree of satisfaction with the technological platform for public purchases ("ChileCompra"), which allows this firm to sell its products to government agencies. However, he is disappointed with the absence of protection of domestic shoes producers and the decreasing incentives to improve workers' capacity through educational programs.