

Innovation and Productivity in Services: Evidence from Chile

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Abstract

This paper analyzes empirically the relationship between innovation and productivity in the Chilean services sector. Consistent with recent evidence on developed countries, we find that services firms are as innovative as firms in the manufacturing industry. In the basic model, we also find that both industries have similar determinants of the investment in innovation and the probability of introducing innovations (products or process), such as size and export status. In several extensions we find similar roles for technological and non-technological innovation in labor productivity and for determinants such as skill intensity and financial restrictions. In general, our evidence suggests that that innovation input and output is associated with improvements in productivity in both sectors. As extension of the work of Crespi and Zuñiga (2012) we test whether financial constraints are more relevant for either manufactures or services, finding that these seem to be active just for the services sector. We also test for the role of skills finding that they play a central role on the decision to spend in R&D and labor productivity.

JEL Classification: O31, O33, L80

Key words: productivity, innovation, services.

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1. Introduction

There is an increasing consensus that the key for long run prosperity in economies stems from productivity growth. This is particularly true in Latin America, where the productivity gap appears to be the most important explanation of why the region is lagging behind not only the developed countries, but other similar countries that have been able to develop in the last 50 years (Daude and Fernández-Arias, 2010; IDB, 2010).

A fundamental ingredient of this poor performance may be the evolution of the services sector. Most of the region has partly skipped a process of industrialization before becoming a “services economy”, by directly shifting resources from agriculture into services. Thus, today most Latin-American economies’ GDP and employment is overwhelmingly driven by the Services sector. In the same direction, the low productivity in the services sector seems to explain an important part of the income and productivity lag of the region (IADB, 2010). Thus, a study of the determinants and constraints for innovation and productivity growth in this sector seems urgent and relevant from a policy point of view.

In Chile, similar to the rest of LAC, the service sector accounts for 60 percent of the total GDP and about 70 percent of the total employment in 2011 (Banco Central, 2012). Indeed, this sector has maintained a major position in the local economy, since early 2000’s, where it concentrated three fourths of Chilean firms and explained 70 percent of the total sales of firms (MINECON, 2008). Thus, boosting innovation in services as engine of productivity growth seems to be central as a development policy objective oriented towards improving the performance of the economy as a whole. Moreover, the significant share of employment hired in the sector gives particular relevance to such objective.

The public support programs directed towards the service sector until recently have been almost non existent. As documented by Bravo-Ortega and Eterovic (2013) Chilean industrial policies experienced a transition from vertical to horizontal policies in the period between 1973 to 2005. Was then with the creation of the National Innovation Council that the discussion on the pertinence of implementing some vertical policies took form. Was this Council who promoted the creation of clusters policies in sectors such as Salmon, Mining and Global Services among others. As documented by Zahler et al (2013), the “Global Services” cluster can be considered the most successful case. Interestingly the government decided to promote a sector that was in its infant stages. The global services cluster was the natural expansion of the “Programa de

Atracción de Inversiones de Alta Tecnología” (PAI) , whose objective was to take advantage of new information and communication technologies, and the believed regional leadership that Chile would have had in this areas for developing a fast growth new exporting sector. In our research we will pay particular attention to knowledge intensive business services (KIBS) in a context in which many of them might have benefited from the public policies developed around the PAI and cluster policies.

The main focus of this research is determining and understanding the drivers of innovation and productivity in the services sector. Considering that the innovation processes within firms are different in service sectors than in manufactures, the policy support and encouragement for innovation and productivity growth in this sector will need new and specific knowledge. Thus, the IADB project seeks to feed the public policy discussion with the results of this and other countries empirical and study cases papers.

Additionally, in this paper we will investigate whether knowledge intensive business services (KIBS) behave differently from traditional services. Indeed, Aboal et al. (2011) find that traditional services are less innovative than KIBS. Therefore, the specific understanding on how innovation and productivity increases occur in this sector has the potential to impact more appropriately the design of innovation policies.

In the case of Chile, an in depth analysis of these determinants is doubly interesting. On the one hand Chile has been carrying innovation surveys for a long period of time using the same methodologies as the state of the art surveys in developed economies¹. Moreover, the four latest rounds of this survey have included the services sector at a one digit ISIC rev 3 level. Chile has also carried two larger surveys (the Encuesta Longitudinal de Empresas - ELE) which will also be used in the analysis.

On the other hand, as previously noted, recent economic and case studies have indicated that several Services subsectors are highly innovative and have expanded abroad through exports and foreign direct investment. This dynamism might partly explain the relative good performance of aggregate productivity in services relative to other Latin American countries (IADB 2011), and provides a great deal of heterogeneity at the micro level to be exploited.

¹ Using as a basis the Oslo manual. See OECD (2005).

The specific objectives of our research are the following: (i) to investigate the relationship among innovation inputs, outputs, and productivity for the services sector in Chile, (ii) to identify and reconfirm the similarity and differences in the innovative activity and its determinants in the service sector compared to manufacturing, (iii) to identify some of the main obstacles to innovation, in special financial constraints, and to analyze how they impact in the probability of innovating, (iv) to analyze what factors enhance the probability of innovating and spending in innovation in a causal sense and compare them with the drivers in the manufacturing sector, and (v) to investigate the role of different types of innovation in productivity and the particular role of R&D.

This paper is structured in the following way. In the second section, we present a brief literature review. In section 3, we describe the data and we show some comparative analysis between manufacturing and service firms. In section 4, we explain the methodology which is mainly based on Crepon et al. (2008). In section 5, we show the results of the basic model. In section 6, we present results for several extensions to the basic model. The conclusions are presented in section 7.

2. Literature Review.

Until very recently the service sector has been unexplored, or directly neglected, as an object of analysis in terms of its role in productivity growth and as a source and driver of innovation in economies. It was usually presumed that services, despite increasing its share in GDP and employment as countries develop, was not an innovative sector and just used technologies developed elsewhere (Tether and Howells, 2007; Gallouj and Savona, 2009; Pavitt 1984). This preconceptions have made the service sector a not very common target of public policies aimed to foster innovation and productivity growth (Pavitt, 1984). Moreover, this view rejected the idea that the service sector can increase the efficiency of related activities. Good examples of the possibilities in efficiency gains can be represented by improvements in traditional services, such as transport, logistics, trade, professional services and telecommunications, which are activities that connect different productive sectors. Moreover, services such as information technologies, telecommunications, and engineering can be considered the building blocks of the innovative capacity of the whole economy, transforming

themselves as engines of long-run growth (Europe Innova, 2011; Sissons, 2011; OECD, 2001).

Tether (2005) indicates that there are two main traditions in the literature about innovation in services. The first one is the denominated “assimilation approach” that considers that innovation in services is similar to innovation in manufacturing. The second one is the called “demarcation approach” contending that innovation in services is highly different than innovation in manufacturing. This approach implicates that new theories and measurements are needed to understand innovation better in the services industry. More recently, according to Tether (2005), a new perspective has flourished. This is the “synthesis approach” arguing that both sectors do not follow completely different innovation paths, but it is necessary to acknowledge that there are some differences in terms of innovation activities pursued in both sectors and how they need to be measured and understood.

Recent evidence on innovation in services from developed economies and some (still scarce) from developing countries² suggests that the services sector is as innovative as the manufacturing sector. Indeed, part of this sector is also significantly tradable and subject to the potential benefits coming from international competition. Tether (2005), using information for several European countries, finds that services firms in fact do innovate, although the propensity to innovate technologically is lower than manufacturing firms. He finds some differences in the innovation orientation of services firms: they are more likely to innovate in organization change than firms in the manufacturing industry. However, he concludes that there is not a unique pattern of innovation among firms in this sector³.

A significant amount of recent research also has shown that the services sector is much more heterogeneous than manufacturing or the primary sector and that the way innovation occurs is in many ways different from traditional technological innovation. Recent research in developed countries has shown that KIBS are even more innovative than manufactures (Evangelista and Savona, 2003; Bogliacino, Lucchese, and Pianta, 2007). The same research, finds that innovations in services tend to be non-technical and consequence of incremental changes that many times do not require formal R&D. Thus, it seems that inputs such as IT, telecommunications, software, training and marketing are more important for innovation in services than in manufactures (Hertog, 2010).

² See Iacovone et al (2012).

³ See also Pires et al. (2008) and Santamaria et al. (2012)

The differences between manufactures and services has been increasingly captured by innovation surveys across the world by including this diversity in the samples and by expanding questionnaires to include issues of “soft” or non-technological innovation⁴. Sirilli and Evangelista (1998) analyze major similarities and differences of services innovation compared with manufacturing. They find a high heterogeneity in technological innovation among sector in the services industry. Interestingly, the evidence shows that innovation expenditure per employee in services is very close to the manufacturing average. They conclude that service and manufacturing sectors show more similarities than differences regarding basic dimensions of the innovation process. Following this literature, in this paper we show evidence for both industries and highlight the main differences and similarities between them.

Analyzing the determinants of innovation and its relation with productivity is particularly relevant in the services sector. It is a novel and relevant research which shed light on some of the causes of the existence or lack of productivity of this sector, with its particularities. It will also enlighten the discussion of policy seeking to promote innovation in services, and how particular or specific should policy be compared to the support already given by default to other sectors of the economy through instruments focused on technological (or “hard”) innovation. There is scarce previous empirical evidence on these issues. Leiponen (2012) studies the determinants of innovation for Finish firms in manufacturing and service industries, focusing on the effects of R&D investments and breadth in knowledge sourcing and innovation objectives. He finds that R&D has a significant effect on innovation for both industries, but the breadth of innovation objectives seems to be detrimental for innovation in services. Cainelli et al. (2006), for Italy, explore the links between innovation and economic performance in services. They find a two-way relationship: innovation is positively affected by firm’s past performance and innovation, particularly investment in ICT, has a positive impact on productivity and growth. In contrast, Gustavsson and Karpaty (2011), following the ideas of Aghion et al. (2005), focus on the relationship between competition and innovation in the Swedish services sector. They find evidence of an inverted U-shaped relation between innovation and competition. In this paper, following closely the model of Crepon et al. (2008), we explore these issues more deeply by studying jointly the determinants of innovation

⁴ See Djellal and Gallouj (2001), Drejer (2004), and Tether et al. (2007), chapter 1.

investment and innovation outcomes, and we look also at the impact of innovation on productivity⁵. We explore not only differences between manufacturing and services, but also between traditional services and KIBS.

3. Data and Descriptive Statistics

We benefit from a wide number of innovations surveys, which have been conducted in the last decade. In total 7 innovation surveys have been conducted. However only the last four surveys cover the services sector. Nevertheless, we will use only a pooled cross-section of 5th and 6th survey (which cover the years 2005-2006 and 2007-2008 respectively) for our base specifications, given that the questions of these two surveys are the most consistent through time⁶. These surveys, with some small variation have maintained standardized questions according to the Oslo Manual, and thus can be used effectively for comparable estimations. The surveys include firms from other relevant sectors such as commodities, which we drop to focus our analysis in the services sector and manufacturing⁷. We will also provide estimations using the Encuesta Longitudinal de Empresas (ELE)⁸.

The services sector (and the survey in general) is subdivided according to an ISIC rev.3 classification of economic activities. The surveys are taken at a disaggregation level of 1 digit. This implies that for the services sector we have 9 subsectors, where we define KIBS as sectors K and I (R&D, transport, communication and real estate services⁹).

The innovation surveys ask quantitative and qualitative questions about innovation inputs and outputs, both technological and non-technological, obstacles for doing innovation as well as sources for cooperation. Some key average descriptive characteristics and comparisons between sectors can be found in tables 1-6 below.

⁵ See Vahter and Masso (2011) for a similar analysis in Estonia's service sector.

⁶ We will provide our results for the base scenario without the use of weights. This is because we have missing values that require reweighting of the data. Nevertheless, in the extensions of the paper we show the results for the same pooled-cross section with the use of weights, as well as the results using the 4th, 5th, 6th and 7th pooled innovation surveys. We tried to build panels using pairs of surveys but the number of data points decreased dramatically since these surveys are not constructed with the goal of forming a panel. Also, the number of observations for each sector varies substantially from survey to survey. For those reasons we abandoned that data strategy.

⁷ In the setup of our database we also drop plants that do not have data for our relevant estimations. In particular, some data points that do not declare sales or employment are dropped from each survey.

⁸ ELE is a much larger firm level survey for the whole economy. There have been two rounds for this survey, ELE1 and ELE2. We provide however results only for ELE1. Again, since this survey was not designed initially as a panel we do not have a match for a significant number of firms and for that reason we will not pursue the use of a panel. Also, ELE 2 unfortunately does not ask any questions regarding R&D, which is an essential input to determine innovation expenditures.

⁹ Unfortunately, the fact that INE provides a disaggregation for the service sector only at the 1 digit level makes it impossible to not consider a subsector such as real estate which is not considered a part of KIBS.

Tables 1 and 2 compare innovation outputs between different sectors. Looking first at aggregate propensities an issue that can be noted is that the service sector produces technological innovative output at a similar (slightly smaller) rate than the manufacturing sector particularly in product innovation, where the percentage of firms that have innovated is 22% in manufacturing and 21.3% in services. In process innovation the difference is larger (26% to 20.8%) but still similar. These small differences in favor of manufacturing can also be seen in the total percentage of innovative firms, the percentage of firms that do in-house technological innovation and the percentage of innovations that are cutting edge (at least new to the domestic market). Also, process innovation seems relatively more prevalent in services than in manufacturing, where firms have a higher propensity to innovate in processes. With respect to non-technological innovation, services firms have a marginally higher propensity to innovate in organizational issues, but the opposite can be observed for marketing innovations, where there is a slight advantage of innovativeness of the manufacturing sector, contrary to conventional wisdom. In both sectors organizational innovations are much more common than marketing innovations. Overall both sectors have a very similar propensity to innovate in technological and/or non-technological innovations.

A more interesting and diverse picture emerges when we disaggregate the service sector into its still-very-heterogeneous subsectors. The most innovative subsector in the analysis is sector K which encompasses business activities and R&D¹⁰. It is significantly more productive in product innovation than all other subsectors, including manufacturing. However, the Utilities sector (particularly in process innovation) and the Health and social services appear as also very innovative. The less innovative subsectors are retail and hotels and restaurants, which is consistent with the fact that these industries are usually of relatively low productivity. Regarding non-technological innovation, subsector K also highlights having a higher propensity to innovate than manufacturing. Here also Health services have very high propensities, being overall higher than the business services sector.

¹⁰ The other sector that we incorporated under the definition of KIBS shows a lower propensity to innovate than many subsectors. It would have been great to include only the telecommunications subsector as part of KIBS. However, as already noted, this was impossible due to the 1-digit level of disaggregation of the 5th and 6th innovation surveys.

Table 1.

Years 2005-2008	Technological Innovation						Non-Technological Innovation			Any Innovation (4)	Tech and Non-Tech Innovation (5)	
	N	CIU	Product (*)	Process	Innovative firms (1)	In-house Tech-Innov (**)	New to Market (***) (2)	Organization	Marketing			Non-Tech Innovation (3)
All Service Industry	4332		21.3%	20.8%	28.4%	23.3%	10.4%	26.6%	12.8%	27.8%	35.2%	21.1%
KIBS												
Real estate, renting and business activities	843	K	31.3%	25.9%	36.5%	25.7%	19.0%	29.8%	17.9%	32.4%	41.8%	27.2%
Transport, storage and communications	870	I	18.9%	18.1%	24.5%	21.3%	9.3%	24.7%	11.2%	25.3%	31.0%	18.7%
Subtotal	1713		25.0%	21.9%	30.4%	23.4%	14.1%	27.2%	14.5%	28.8%	36.3%	22.3%
Traditional Services												
Electricity, gas and water supply	212	E	13.2%	32.1%	34.0%	34.2%	7.6%	29.7%	5.7%	29.7%	43.9%	19.8%
Construction	638	F	18.8%	23.0%	29.2%	22.3%	8.2%	28.1%	8.5%	29.5%	36.2%	22.4%
Wholesale and retail trade and repair of equipment	569	G	12.7%	11.6%	17.8%	15.6%	5.6%	19.0%	12.0%	19.5%	24.8%	12.5%
Hotels and restaurants	180	H	15.6%	14.4%	21.7%	18.9%	7.2%	18.3%	11.7%	18.9%	25.0%	15.6%
Financial intermediation	344	J	20.9%	19.2%	26.2%	26.9%	7.9%	28.5%	15.1%	29.9%	34.6%	21.5%
Health and social services	380	N	29.0%	25.3%	38.2%	28.2%	7.9%	36.1%	14.2%	37.1%	46.1%	29.2%
Other community and social and personal services	296	O	21.3%	19.6%	26.4%	23.5%	12.8%	22.6%	15.5%	24.7%	32.8%	18.2%
Subtotal	2619		18.8%	20.1%	27.2%	21.3%	7.9%	26.2%	11.7%	27.2%	34.4%	20.0%
National and Foreign Capital												
National	3896		20.8%	20.3%	27.9%	22.1%	9.7%	26.4%	12.7%	27.6%	34.6%	20.9%
Foreign (****)	436		25.0%	25.5%	33.7%	22.9%	16.3%	28.4%	13.5%	29.8%	40.4%	23.2%

(1) Product or process innovation

(2) New to Market product innovation

(3) Organization or marketing innovation

(4) Technological or non-technological innovation

(*) In the product definition for all cases we include both new goods and services

(**) This definition is only available for the 6th innovation survey

(***) For the 5th survey, this definition refers to innovations that are new to the domestic market or to the world

(****) We consider a company "foreign" if at least 1% of the property belongs to non-residents

Table 2.

Years 2005-2008	Technological Innovation						Non-Technological Innovation			Any Innovation (4)	Tech and Non-Tech Innovation (5)	
	N	CIU	Product (*)	Process	Innovative firms (1)	In-house Tech-Innov (**)	New to Market (***) (2)	Organization	Marketing			Non-Tech Innovation (3)
All Manuf. Industry	2,860	D	22.0%	26.0%	31.5%	26.3%	13.4%	24.9%	17.5%	28.0%	36.8%	22.7%
National and Foreign Capital												
National	2567		21.1%	24.8%	30.3%	25.2%	12.2%	24.2%	17.0%	27.1%	35.8%	21.6%
Foreign (****)	293		30.0%	36.5%	42.3%	36.6%	23.6%	31.4%	22.5%	36.5%	46.1%	32.8%

Table 2 shows a comparison between fully domestic firms with those with some foreign participation. In both manufacturing and services, and in technological and non-technological innovation, firms with foreign capital have a higher propensity to innovate. Interestingly the difference between domestic and foreign firms is much larger in manufacturing than in services.

Innovation inputs can be seen in Tables 3 and 4. Overall, services firms spend more in innovation than manufacturing firms. This is particularly driven by the large expenditure of subsector K which has more than double the expenditure than manufacturing as a percentage of sales. KIBS as a group also innovates more than manufacturing and more than non-KIBS subsectors. However, unexpectedly, health services, community and social services, and hotels and restaurants have a high level of expenditure in innovation, higher even than manufacturing, a fact that is difficult to explain. When we decompose the expenditure between R&D, machinery and other innovation expenditures, R&D has a much larger weight in manufacturing than in services (larger than KIBS too), where 21.7% of expenditure corresponds to R&D. The most R&D intensive subsectors in the services industries, are subsector K (which shows a higher importance of R&D than manufacturing) – 23.7%, and financial intermediation (18.6%). Health services and hotels concentrate their innovation expenditure in equipment when compared to the most R&D intensive sectors, and show lower importance in R&D as should be expected. The percentage of firms that performed R&D is again higher in manufacturing (15.5%) than in services (8.4%) and than in KIBS (11.3%), but again also subsector K has the highest percentage of firms spending in R&D (16.8%). Financial intermediation is the other subsector that has more than 10% of firms spending R&D. When comparing domestic with firms with foreign participation the latter, despite having a larger propensity to produce innovative outputs, they tend to spend less on innovation than their domestic counterparts. Domestic firms in the service sector spend 7.1% of sales on average as opposed to 5.3% for firms with foreign participation. For the case of manufacturing, the difference is more marked, 6.3% vs 2.6%. Despite spending less on average foreign owned firms have a higher propensity to spend in R&D overall, suggesting that the larger expenditure in domestic firms is driven by few heavy spenders.

Table 3.

Years 2005-2008		Inputs							Outputs	
N	CIU	Expenditure on innovation (6)	R&D (7)	Machinery Acquisition (8)	Other Innovation activities (9)	Firms that performed R&D	Firms that performed R&D on a continuous basis	Turnover from product innovations	Turnover from new to market product innovations (*)	
All Service Industry	4332	6.3%	12.6%	52.1%	35.3%	8.4%	N/A	6.6%	1.6%	
KIBS										
Real estate, renting and business activities	843	K	13.6%	23.7%	36.9%	39.3%	16.8%	N/A	11.1%	2.6%
Transport, storage and communications	870	I	4.6%	10.5%	58.4%	31.1%	5.9%	N/A	4.9%	1.3%
Subtotal	1713		9.0%	17.0%	47.9%	35.1%	11.3%	N/A	8.0%	1.9%
Traditional Services										
Electricity, gas and water supply	212	E	3.1%	8.0%	49.0%	43.0%	7.6%	N/A	2.2%	1.1%
Construction	638	F	3.9%	10.2%	55.1%	34.7%	6.9%	N/A	6.7%	1.6%
Wholesale and retail trade and repair of equipment	569	G	2.6%	2.6%	67.1%	30.2%	1.2%	N/A	3.1%	1.1%
Hotels and restaurants	180	H	6.5%	5.9%	67.0%	27.1%	3.3%	N/A	6.5%	1.6%
Financial intermediation	344	J	2.6%	18.6%	34.4%	47.0%	11.6%	N/A	5.0%	1.7%
Health and social services	380	N	7.9%	9.7%	54.1%	36.2%	8.7%	N/A	8.4%	0.2%
Other community and social and personal services	296	O	7.3%	15.4%	53.0%	31.6%	8.8%	N/A	7.4%	1.7%
Subtotal	2619		4.5%	9.7%	54.9%	35.4%	6.6%	N/A	5.6%	2.1%
National and Foreign Capital										
National	3896		7.1%	13.0%	52.0%	35.0%	8.3%	N/A	6.3%	1.5%
Foreign	436		5.3%	16.3%	41.3%	42.4%	9.9%	N/A	9.5%	2.6%

(6) Total expenditures on innovation (as a % of total turnover)

(*) This information is only available for the 6th innovation survey

(7) Expenditure on R&D as a % of total expenditure on innovation

(8) Expenditure on machinery acquisition as a % of total expenditure on innovation

(9) Expenditure on the rest of innovation activities as a % of total expenditure on innovation

Table 4.

Years 2005-2008		Inputs							Outputs	
N	CIU	Expenditure on innovation (6)	R&D (7)	Machinery Acquisition (8)	Other Innovation activities (9)	Firms that performed R&D	Firms that performed R&D on a continuous basis	Turnover from product innovations	Turnover from new to market product innovations	
All Manuf. Industry	2,860	D	6.0%	21.7%	45.4%	33.0%	15.5%	N/A	5.5%	1.5%
National and Foreign Capital										
National	2567		6.3%	20.6%	45.7%	33.7%	14.2%	N/A	5.5%	1.5%
Foreign	293		2.6%	28.7%	43.1%	28.2%	26.6%	N/A	5.3%	1.6%

However, despite this issue, firms with foreign capital dedicate a larger proportion of their innovation expenditures to R&D, both in services and manufacturing. Finally, the turnover from innovative products is higher in the services industry than in the manufacturing industry, and again particularly high in subsector K and the KIBS group in general. Turnover from products new to the markets is generally very low (less than 3% of sales) with the same mentioned pattern.

Turning to policy relevant innovation behavior, tables 5 and 6 show first the well-known fact that manufacturing firms are significantly more export oriented than services firms. Chile is not the exception and the data shows that 31.4% of manufacturing firms export, compared to 8.6% of services firms. Exporting propensity is heavily biased to foreign capital firms in both sectors: 65% of those firms in manufacturing and 19.3% in services export, compared to 27.5% and 7.4% respectively. KIBS industries have a higher propensity to innovate than the rest of services. However, unexpectedly some traditional services subsectors appear as having a relatively high propensity to export. Such is the case of wholesale and retail trade, and hotels and restaurants.

Cooperation, which part of the literature associates with services rather than manufacturing appears also more prevalent services en Chile. Again, KIBS show a marginally higher cooperating pattern than services in general, again foreign firms in both sectors are much more prone to cooperate (particularly with foreign partners, unsurprisingly). Firms that had public support for innovation are also more likely to come from the service sector (6.9% of firms as compared to 4.7%; KIBS 8.1%). This is surprising since one would think that public support tends to be biased towards more measurable innovation outputs, which happen more clearly in manufacturing. Patent applications are more prevalent in manufacturing, which is to be expected since it is harder to patent in services due to lower appropriability of new ideas. In the services sectors, only subsector K (which includes R&D activities) has a similar propensity of patent application.

Finally, we added three variables that we include in the regressions and extensions and that we thought are important to analyze descriptively. The first one is firm size (measured as the number of employees), where the average services sector firm in the sample appears to be larger than the manufacturing firm (except for community and social services). Foreign capital firms are significantly larger than domestic firms. Second, we also want to compare

measures of skills, since the empirical recent literature stresses the fact that one of the main differences between both sectors is a skill bias of the services sector. We included two measures available in the innovation surveys: the proportion of employment that has tertiary education and which is dedicated to R&D, and the proportion of total employment that has a professional or technical degree. The latter shows a more complete picture of skills but it is only available for the 6th innovation survey. Regarding the first measure, the data does not seem to confirm the greater skill intensity in services, as both sectors show similar intensity. The exception is subsector K which has a significantly larger proportion of employment dedicated to R&D, which also drives the KIBS industry to have a higher figure when compared to manufacturing. Regarding the more general measure of skills we do observe an important difference across the board in favor of services, where this sector has almost double the qualified personnel when compared to manufacturing. The largest skill intensity can be observed again in financial intermediation, business activities and health services.

Table 5.

Years 2005-2008											
	N	CIU	International markets (10)	Co-operated with foreign partners (11)	Co-operated (12)	Co-operated with Universities or Gov. (13)	Public Support (14)	Applied for patents (15)	Size (*)	Skills 1 (**)	Skills 2 (***)
All Service Industry	4332		8.6%	13.5%	36.3%	13.4%	6.9%	1.8%	187.8	1.1%	46.3%
KIBS											
Real estate, renting and business activities	843	K	10.6%	21.6%	42.6%	18.2%	9.7%	3.8%	151.3	3.1%	58.9%
Transport, storage and communications	870	I	9.7%	11.9%	32.2%	8.9%	6.7%	1.6%	161.2	0.5%	44.7%
Subtotal	1713		10.1%	16.6%	37.3%	13.5%	8.1%	2.7%	156.3	1.8%	51.7%
Traditional Services											
Electricity, gas and water supply	212	E	1.4%	22.6%	46.2%	21.5%	1.1%	0.0%	135.8	0.9%	51.1%
Construction	638	F	3.3%	7.4%	31.2%	11.3%	7.4%	1.9%	277.3	0.8%	27.0%
Wholesale and retail trade and repair of equipment	569	G	18.6%	5.7%	28.4%	8.5%	7.1%	0.7%	166.1	0.1%	35.4%
Hotels and restaurants	180	H	14.4%	4.4%	17.8%	0.0%	6.7%	0.0%	207.3	0.3%	19.9%
Financial intermediation	344	J	3.2%	18.5%	43.7%	13.5%	2.5%	0.3%	331.5	1.1%	67.8%
Health and social services	380	N	0.8%	10.3%	42.9%	22.3%	6.9%	2.1%	175.5	0.5%	58.8%
Other community and social and personal services	296	O	9.5%	21.7%	43.3%	17.5%	7.2%	3.0%	93.5	0.9%	49.3%
Subtotal	2619		7.6%	11.5%	35.6%	13.3%	6.0%	1.3%	208.5	0.6%	42.8%
National and Foreign Capital											
National	3896		7.4%	6.9%	17.5%	7.5%	3.9%	1.8%	173.9	1.1%	42.4%
Foreign	436		19.3%	17.0%	28.0%	11.4%	3.2%	2.3%	313.3	0.9%	60.7%

(10) Share of firms that were active on international markets

(11) Share of firms that co-operated with foreign partners on innovation

(12) Share of firms that co-operated on innovation activities

(13) Share of firms that co-operated with Universities/Higher education or government research institutes

(14) Share of firms that received public financial support for innovation

(15) Share of firms that applied for one or more patents

(*) Average number of employees

(**) total number of professionals dedicated to R&D as a percentage of direct employment

(***) Percentage of professionals and technicians in total employment (direct and indirect).

Information only available for the 6th innovation survey

Table 6.

Years 2005-2008											
	N	CIU	International markets (10)	Co-operated with foreign partners (11)	Co-operated (12)	Co-operated with Universities or Gov. (13)	Public Support (14)	Applied for patents (15)	Size (*)	Skills 1 (**)	Skills 2 (***)
All Manuf. Industry	2,860	D	31.4%	9.7%	22.7%	9.7%	4.7%	3.9%	126.4	1.2%	26.6%
National and Foreign Capital											
National	2,567		27.5%	8.5%	21.5%	9.2%	4.9%	3.9%	110.3	1.2%	26.1%
Foreign	293		65.2%	20.7%	33.9%	13.7%	3.8%	4.4%	267.5	1.2%	31.5%

Overall, the descriptive statistics confirm the recent empirical literature, indicating that the services sector is as innovative as manufacturing, albeit with significant heterogeneity within it. The KIBS industry is generally the most innovative within services, although we find some strikingly innovative subsectors. Interestingly, there are no appreciable differences in both technological and non-technological innovation between services and manufacturing.

Something similar can be said about innovation inputs. However, manufacturing is more focused in R&D than the services industry, except for subsector K within KIBS. Turnover from innovative products seems higher in services than in manufacturing in Chile. As could be expected services seems more inclined to cooperate to innovate than manufacturing, significantly less export oriented than manufacturing, and more skill intensive.

In the next section we explain the methodological approach used for our estimations.

4. Methodology

Our methodology follows the empirical research line initiated by the influential work of Crépon, et al. (1998) to look at the relationship between innovation investment, innovation outcomes and firm productivity. This approach is based on a multi-equation model that takes into account the whole process of innovation thereby considering the decisions of the firms to engage in innovation activities, the results of these efforts, and their impact on productivity.

Following the CDM approach, our baseline model consists of four equations: (i) the firm's decision to invest in innovation, (ii) the intensity of the investment in innovation, (iii) the knowledge production function linking innovation intensity and innovation outcomes, and (iv) the output production function, in which firm productivity is a function of innovation outcome and other control variables. This basin set up is extended in the following sections to look at the impact other obstacles to innovation, such as financial constraints.

To compare with previous results using this methodology with innovation surveys for manufacturing firms in developing countries, we follow closely the specification employed by Crespi and Zuñiga (2011). First, we estimate a generalized Tobit that considers the decision to invest and the amount invested in innovation. Second, we use the predicted value of innovation intensity (innovation investment per employee) as explanatory variable in the knowledge production function, where the innovation outcome is measured by a categorical variable that

account for product and process innovation. Finally, the predicted values of innovation outcomes are used as explanatory variables in the output production function¹¹.

In our empirical exercise we explore several hypothesis related mainly to the differences that might exist between manufactures and services, and within them the differences from the overall sector and KIBS.

We investigate whether size matters as determinant of innovation – a traditional result for manufactures (See Crepon et al (1998), Griffith et al (2006)). Given that in the services sectors innovations tend to be more incremental and demand lower amount of resources we also investigate whether financial constraints turn to be not as important as in manufactures (See Alvarez and Crespi (2011)). Given the material nature of manufactures and the immaterial essence of services we expect different importance of patent protection between sectors. Having present that in the mind of policy makers that design public support programs might have had the preconception that services sectors are less innovative by nature, and that hence public programs may be tailored to manufactures we expect different effects of participation in public support programs on innovation activity. When studying the differences between manufactures and services we devote important efforts to investigate whether the level of skilled workers matter more for services than in manufactures (See Iacovone et al (2012), Pires et al (2008) among others), although the service sector in Latin America has traditionally been considered demanding a lower qualification level than manufactures.

Additionally, in our estimations we pay particular attention to the differences that might exist between KIBS and the overall service in particular taking into account that KIBS have a higher propensity to innovate (See Evangelista et al. (2003) Bogliacino et al.(2007)).

4.1.1. Innovation Investment

We rely on a generalized Tobit framework to model the decision to invest and the amount invested in research activities. Hence, there are two linked equations: (i) the decision to invest in innovation, and (ii) the amount of resources involved, measured as innovation expenditure per employee (in logs). More precisely, we assume that there exists a latent dependent variable IE_i^* for firm i 's innovative effort, given by the following equation:

¹¹ This model may be estimated using alternative econometric techniques as Asymptotic Least Squares, as actually done in the original paper by Crépon, et al. (1998). However, recent works on this issue tend to prefer the less computationally intensive technique of estimating the three components of the model separately using instrumental variables (Griffith et al 2006; Hall et al 2008).

$$IE_i^* = X_{li}'\beta + \varepsilon_i \quad (1)$$

where X_{li}' is a vector of explanatory variables, β is a vector of parameters and ε an error term. The econometrician observes that (log) resources are invested in innovation activities, IE_i , if IE_i^* is positive or larger than a given threshold.

We assume the following selection equation describing whether a firm is investing in innovation or not:

$$ID_i = 1 \quad \text{if} \quad ID_i^* = W_i'\alpha + e_i > c, \quad \text{and} \quad 0 \quad \text{otherwise.} \quad (2)$$

Where ID is an observed binary variable equal to zero for firms not investing in innovation and 1 for those investing in innovation, ID_i^* is the corresponding latent variable such that a firm decided to invest in innovation if it's above a certain threshold denoted by c , and W is a vector of explanatory variables.

Conditional on investing, the observed innovation investment (IE_i) is given by:

$$IE_i = \begin{cases} IE_i^* = Z_i'\beta + \varepsilon_i & \text{if } ID_i = 1. \\ 0 & \text{if } ID_i = 0. \end{cases} \quad (3)$$

The system of equations (2) and (3) is estimated as a generalized Tobit model by maximum likelihood.

The vector of explanatory variables W and Z follows closely those used by Crespi y Zuñiga (2011). Therefore, we model the firm's decision on whether to invest in innovation considering the following explanatory variables:

- Export: defined as dummy variable for exporters. This variable is used to capture the exposure to international markets that it is expected to increase innovation exports through higher competition and learning effects.
- Firm size: defined as the number of workers (in logs) and it is expected to affect innovation investment positively (Cohen and Levin, 1989).
- Foreign ownership: defined as dummy variable for foreign owned firms. We expect a positive effect in case that foreign owned firm can access to technological information that it is not available for domestic firms. However, previous evidence on the manufacturing firms in Latin America is not conclusive on this positive effect (Crespi and Zuñiga, 2011).

- Patent protection: a dummy equal to one if the firm filed for a patent in the previous period. This variable is included to control for the capacity of the firm to manage intellectual property rights and its past stocks of knowledge. Both should be positively correlated with innovation investment.

The set of explanatory variables for innovation intensity includes the variables defined above and the following additional ones:

- Cooperation: It is captured by a dummy variable that takes the value 1 if the firm has some cooperative arrangement on innovation activities.
- Public finance: defined as a dummy variable that indicates whether the firm uses public resources for funding R&D investments.
- Sources of information: We consider 3 possible sources and we define these variables as the scores measuring the importance of the following different sources for innovation: (i) market (suppliers, clients, competitors, etc.) (ii) Scientific (universities, public research centers, etc.) and (iii) public (journals, patents, magazines, etc.).

4.1.2. Knowledge Production Function

In general, it is assumed that innovative output is related to improvements in firm's productivity. There are, however, several ways to proxy innovation output. The most common proxies used in this literature are the number of patents and share of innovative sales. In this paper, in our basic regressions we use one indicator of innovation output. This is defined as dummy variable indicating if the firm declares having introduced either a product or process innovation.

The surveys include several alternatives for product and process innovation. In the case of product innovation, firms are asked for technological improvements of products and introduction of a new product for the firms but not new for the market. For innovation process, the approach is similar. Firms are asked for partial but important improvements and for new technological process for the firm, but not new in the market. Then, we define a product and process innovation if the firm responds affirmatively to any of these alternatives, independently if the product (or process) innovation is new to the firm or to the market.

We estimate a probit model for product and process innovation. This is modeled as follows:

$$I_i = \delta I E_i^* + Y_i' \gamma + \mu_i \quad (4)$$

Where I_i is equal to 1 whether the firm has introduced either a product or process innovation. IE_i^* is the predicted value of the firm innovative effort (log of innovation investment per worker) from the estimated generalized Tobit equations described above, and Y_i' is a vector of explanatory variables. This instrumental variable estimation, given by inclusion of the predicted value of IE_i^* , takes into account the potential endogeneity of investment in innovation. In our basic regressions, following Crespi and Zuñiga (2011), we consider the following explanatory variables: (i) the predicted values of innovation intensity obtained from the Tobit model, (ii) firm size defined as above, (iii) a dummy for exporting firms, and (iv) a dummy for foreign owned firms.

The basic identifying assumption in this methodology is that there are some variables affecting the decision of investing in innovation that do not affect the innovation outcome. There are several variables – included in innovation decisions but not innovation outcomes - for which this assumption is likely to hold. Let us consider, for example, the use of public resources. It can be argued that, in the presence of financial constraints, public resources are useful for financing innovation. However, it is difficult to argue that public financing may increase directly the probability of introducing new products or new technological process. By the same token, the variables that identify the sources of innovation are likely to affect the resources invested in innovation, but not necessarily the innovation outcomes.

4.1.3 Output Production Function

Assuming a Cobb-Douglas production function, the effect of innovation on productivity may be estimated with the following specification:

$$y_i = \alpha_1 k_i + \alpha_2 I_i + v_i \quad (5)$$

Where y is labor productivity (log of sales per worker), k is log of capital per worker, I is the knowledge input proxied by product and process innovation. One way to deal with the endogeneity of these innovation variables is to introduce in equation (5) the predicted values of the innovation variables from equation (4). As in the previous equation, the identification assumption is that some variables included in knowledge production function, specifically the use of information from several sources, affect the probability of introducing innovations, but not

directly the productivity of the firms. As additional covariates for explaining productivity, we include the size of the firms and the share of new equipment over total equipment expenditures¹². It is important to note that we for estimations of the output production function, we will use lagged values of all the independent variables. In other words, the labor productivity in t will always be regressed against independent variables in $t-1$ ¹³.

5. Basic Results

a. Main estimations

In this section, we present the results of our specification following the model specification form Crespi and Zuñiga (2011). We begin first by showing and explaining the main variables used in our estimations. These are shown in Table 7 below.

¹² Given that we have no information on capital per worker for almost all the period, we use this imperfect measure for controlling by differences in capital across firms. Moreover, this measure is only available for the 5th innovation survey. For this reason we will present also results for both the pooled cross section, without this variable.

¹³ The only exception to this will be the estimations made with the ELE survey which ask questions only for one year, unlike the innovation surveys which always ask for two years of information.

Table 7: variables used in estimations

Dependent Variables		Definition
Technological Innovation	TI	Dummy equal to one if the firm introduced product or process innovation
Expenditures on innovation activities per emp.	IE	Log of innovation expenditures per employee
Productivity	Y	Log of sales (Y) per employee
Independent Variables		
Firm Size	EM	Log of the number of employees at the start of the reporting period
Export	EX	Dummy equal to one if the firm exports at the start of the reporting period
Foreign Ownership	FO	Dummy equal to one if foreign capital ownership is above 0% at the start of the reporting period
Patent Protection	PA	Dummy equal to one if the firm filed for a patent in the previous period
Cooperation	CO	Dummy equal to one if the firm is engaged in collaboration for R&D
Public Finance	FIN	Dummy equal to one if the firm received public support to finance innovation
Importance of market sources of information	INFO1	Score measuring the importance of suppliers, clients, competitors, consulting firms, and experts.
Importance of scientific sources of innovation	INFO1	Score measuring the importance of universities, public research center, technological institutions
Importance of public sources of information	INFO3	Score measuring the importance of journals, patents, magazines, expositions, associations, databases, Internet.
High Technical Risk constrain	C1	Dummy equal one if manager perceive that High technical risk is one of the most important innovation constraint.
Easy to imitate innovation constraint	C2	Dummy equal one if the manager perceive that the innovation is too Easy to imitate and thats is very important constraint.
New Equipment	EQ	% of new equipment in 3 years over total equipment

We first present the results for the innovation investment model for our base specification (manufacturing vs services), which can be seen in Table 8.¹⁴

¹⁴ Table 8 shows the marginal effects of Heckman estimation models for expenditure in innovation. All regressions incorporate sector fixed effects at the 1 digit level, given that only one survey provided two-digit disaggregation, albeit only for manufacturing. Given that we do not have this information for manufacturing industries, we do not perform regression for low and high tech sectors.

Table 8: First stage estimation of probability and intensity of innovation expenditure (marginal effects shown)

VARIABLES	(1)	(2)	(3)	(4)
	Manufacturing	Services	Traditional Serv	KIBS
5th and 6th Innovation Surveys 2005-2008				
<i>Selection (prob of spending in innov)</i>				
Exporting	0.0786*** (0.0232)	0.0648** (0.0286)	0.0403 (0.0377)	0.0965** (0.0435)
Foreign	0.0232 (0.0309)	0.0139 (0.0244)	0.0258 (0.0323)	0.000621 (0.0375)
Size	0.0974*** (0.00720)	0.0553*** (0.00325)	0.0565*** (0.00423)	0.0510*** (0.00555)
Patent Protection	0.359*** (0.0526)	0.307*** (0.0528)	0.365*** (0.0790)	0.273*** (0.0714)
<i>Intensity (log amount spend in innov per employee)</i>				
Exporting	0.645*** (0.157)	0.425** (0.200)	0.234 (0.281)	0.548* (0.284)
Foreign	0.318 (0.194)	0.0983 (0.233)	0.443 (0.277)	-0.207 (0.370)
Public financial support	0.276 (0.218)	0.472** (0.225)	0.170 (0.331)	0.814*** (0.289)
Patent Protection	0.258 (0.224)	0.662*** (0.237)	0.504 (0.359)	0.627** (0.319)
Co-operation in R&D	0.533*** (0.139)	0.677*** (0.124)	0.409*** (0.159)	1.019*** (0.197)
Market info sources (INFO1)	-0.0647 (0.174)	0.151 (0.172)	-0.00636 (0.236)	0.199 (0.244)
Scientific sources (INFO2)	-0.000433 (0.102)	-0.120 (0.101)	-0.0459 (0.139)	-0.196 (0.138)
Other spillovers (INFO3)	0.00751 (0.148)	0.00709 (0.128)	-0.145 (0.165)	0.198 (0.186)
Observations	2682	4023	2,421	1,602
Robust standard errors in parentheses				
*** p<0.01, ** p<0.05, * p<0.1				

Comparing manufacturing and services (specifications 1 and 2), we find that size is important for both sectors as a determinant of the decision to spend in innovation. This is similar to previous findings in Chile and Latin America. However, our results show that it is consistently more important in manufacturing. This coincides with papers such as Iacovone et al (2012) where they find that size is more relevant for manufacturing to engage in innovation and exports. Also, the results show that exporting firms have a higher probability in engaging in innovation investment in both sectors. In contrast, foreign ownership doesn't seem to be

correlated with this probability, and patent protection appears to be positively correlated.

With respect to the intensity equation, again exporting appears to be positively correlated with higher innovation expenditure, with the effect being stronger for manufacturing. Public financial support is positively correlated with larger expenditure particularly for the service sector. The other relevant variable is having sources of cooperation for R&D. For both manufacturing and services having cooperated to do R&D allows firms to leverage resources and seems to incentivize larger expenditure in innovation. Finally, all sources of information for innovation appear as non-significant and in some cases with opposite than expected sign. Overall, we do not observe many differences between sectors for the selection and intensity of expenditure in innovation. This may be so because the types of expenditure that are recorded for innovation are clearly intended to measure technological innovation and it is possible that the behavior and determinants in both sectors towards that type of innovation might be similar.

Specifications 3 and 4 separate the analysis of services between KIBS and traditional services. Interestingly, for the selection equation exporting is positively associated with the decision to spend only in KIBS. Size and patent protection are similarly relevant in both subindustries. The later results statistically significant in all estimations, but it is more important for manufactures, than for services overall and KIBS in particular.

For the intensity equation, exporting seems again more important for KIBS and not being significant for the decision to innovate in traditional services. Patent protection unexpectedly appears as non-significant for either industry even though when put together the coefficient is significant. Cooperation appears to have 3 times the impact in KIBS than in traditional services. And all sources of information still appear as non-significant.

Second, we show the knowledge production function in Table 9, where we use the predicted (log) expenditure in innovation per employee estimated in the first stage. The probability of introducing a new product or process is positively and significantly determined by the expenditure in innovation. The predicted innovation expenditure has a bigger impact in the probability of introducing technological innovations in manufacturing revealing a closer relationship between both. Firm size again has a clear positive relation with the introduction of a new product or service, on top of its effect on the size of innovation expenditure. This is also consistent with previous evidence in Crespi and Zuñiga (2011) for manufacturing firms Latin

American countries. For all countries considered in that work, larger firms are more likely to innovate even after controlling for the innovation expenditures. And again, as in the predicted value of innovation expenditure, the importance of size is larger (double) for manufacturing in the probability of innovating when compared to services.

Table 9: 2nd stage estimation: Probability of innovating in products, services or processes (probit marginal effects shown)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	5th and 6th Innovation Surveys 2005-2008				Traditional Serv		KIBS	
	Manufacturing		Services		Traditional Serv		KIBS	
<i>Innovation output in product or process</i>								
IE_p (predicted Inn exp per employee)	0.603*** (0.0565)		0.494*** (0.0469)		0.286*** (0.0486)		0.480*** (0.0465)	
Size	0.0753*** (0.00812)	0.0861*** (0.00768)	0.0347*** (0.00411)	0.0453*** (0.00394)	0.0438*** (0.00497)	0.0488*** (0.00493)	0.0318*** (0.00675)	0.0391*** (0.00650)
Export (dummy)	-0.391*** (0.0348)	0.112*** (0.0236)	-0.247*** (0.0207)	0.0677** (0.0299)	-0.0863** (0.0377)	0.0559 (0.0410)	-0.302*** (0.0252)	0.0853* (0.0439)
Foreign Ownership (dummy)	-0.204*** (0.0262)	-0.0105 (0.0300)	-0.0764*** (0.0239)	0.00988 (0.0249)	-0.140*** (0.0323)	0.0142 (0.0337)	0.132*** (0.0439)	0.00594 (0.0371)
Observations	2,688	2,688	4,023	4,023	2,421	2,421	1,602	1,602
Robust standard errors in parentheses								
*** p<0.01, ** p<0.05, * p<0.1								

An interesting unexpected outcome is the exports dummy coefficient. It is consistently negative and significant. Controlling for the predicted intensity in innovation expenditure and firm size exporting firms have a lower probability of having innovation outputs, and this effect is larger for manufacturing. This is counterintuitive, since exporting firms generally have higher exposure to international competition and thus should have a positive (Schumpeterian) relation with innovation. One alternative is that there is an active learning by exporting process behind. If exports affect innovation effort positively and this effort is channeled by investing, we might as well recover a negative coefficient on exports. Indeed, we find evidence at this regard by dropping investment in R&D and leaving the export dummy alone, where we recover a positive sign for the export dummy (estimations 2,4,6 and 8). Finally, firms with foreign ownership have a lower probability of innovating in both sector, but the negative effect is again larger in manufacturing.

When dividing services between KIBS and traditional services, we find that the impact of innovation expenditure on the probability of innovating is much larger in KIBS, which in turn is smaller than in manufactures. We believe that Marin et al (2013) interpretation of Jaffe

(1986) and the consequent relationship between R&D expenditure and innovation captures the easiness to innovate, which would be greater in manufactures, smaller in KIBS and even smaller in traditional services. On the contrary, size appears to be marginally more relevant for traditional services, and still for both much smaller than for manufacturing. The negative association of exporting with the probability of innovating seems driven by the KIBS industry.. Finally, the effect of foreign ownership is very different between the two subindustries. The negative coefficient of specification 3 seems mostly driven by the traditional services. For KIBS the effect is positive and significant.

Finally, in table 10 we show the econometric results for the output production function.

Table 10: output production function

Specification 1: using predicted probability of innovation output								
	whitout new equipment				with new equipment			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
5th and 6th Innovation Surveys 2005-2008								
VARIABLES	Manufacturing	Services	Traditional Serv	KIBS	Manufacturing	Services	Traditional Serv	KIBS
<i>log labor productivity (sales per worker)</i>								
TI_p (Technological innovation)	1.337*** (0.190)	0.737*** (0.148)	1.896*** (0.374)	0.570*** (0.185)	1.114*** (0.214)	0.771*** (0.211)	1.057*** (0.308)	0.816*** (0.229)
Size	-0.0123 (0.0329)	-0.321*** (0.0188)	-0.358*** (0.0274)	-0.347*** (0.0248)	0.0432 (0.0448)	-0.198*** (0.0343)	-0.232*** (0.0449)	-0.160*** (0.0426)
New Equipment					0.00149 (0.00173)	0.00164 (0.00182)	0.000513 (0.00231)	0.00257 (0.00200)
Constant	10.14*** (0.0952)	11.00*** (0.129)	12.64*** (0.171)	11.57*** (0.121)	9.915*** (0.139)	10.59*** (0.167)	10.65*** (0.133)	10.38*** (0.180)
Observations	2,688	4,023	2,421	1,602	1,415	1,359	878	518
R-squared	0.041	0.197	0.236	0.137	0.050	0.149	0.188	0.058
Bootstrapped standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1								
Specification 2: using predicted innovation expenditure per employee								
	whitout new equipment				with new equipment			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
5th and 6th Innovation Surveys 2005-2008								
VARIABLES	Manufacturing	Services	Traditional Serv	KIBS	Manufacturing	Services	Traditional Serv	KIBS
<i>log labor productivity (sales per worker)</i>								
Size	-0.0353 (0.0280)	-0.305*** (0.0149)	-0.288*** (0.0211)	-0.336*** (0.0230)	-0.00471 (0.0366)	-0.181*** (0.0263)	-0.200*** (0.0351)	-0.139*** (0.0397)
IE_p (predicted Inn exp per employee)	0.736*** (0.0548)	0.384*** (0.0449)	0.650*** (0.0915)	0.238*** (0.0589)	0.753*** (0.0731)	0.431*** (0.0697)	0.526*** (0.136)	0.260*** (0.0731)
New Equipment					0.00116 (0.00165)	0.00173 (0.00171)	0.000335 (0.00229)	0.00290 (0.00209)
Constant	7.367*** (0.194)	10.26*** (0.140)	10.86*** (0.296)	11.34*** (0.187)	6.950*** (0.265)	9.058*** (0.283)	10.93*** (0.457)	9.546*** (0.305)
Observations	2,688	4,023	2,421	1,602	1,415	1,359	878	518
R-squared	0.099	0.204	0.247	0.141	0.104	0.157	0.200	0.058
Bootstrapped standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1								

To deal with endogeneity problems we use the predicted values of innovation outputs (specification 1) and innovation inputs (specification 2) as innovation expenditure. In the first two regressions we show a comparison between manufacturing and services. In the second two we compare traditional services with KIBS. We added four additional regressions because the variable for new equipment is only available for the 5th survey. For that reason we provide results using that variable (regressions 5 to 8) and not using it while using both surveys pooled (regressions 1 to 4). As in the previous equation, the identification assumption is that some variables included in knowledge production function, specifically lower appropriability and the interaction with suppliers and customers, affect the probability of introducing innovations, but not directly the productivity of the firms. Also, as in Crespi and Zúñiga (2011), since we use estimated independent variables rather than the actual ones, we need to correct for the standard errors in the equations for innovation output and the knowledge production function. This is done by bootstrapping.

The estimations show that in both manufacturing and services the knowledge inputs have a significant positive impact in labor productivity. This is generally the case for both specification 1 (using the predicted probability of producing innovation), and specification 2 (using the predicted expenditure in innovation). In both specifications 1 and 2 the impact of the knowledge input in labor productivity seems larger for manufacturing than for services. Interestingly, as in the case for exports for the knowledge production function, now when controlling for predicted knowledge inputs, size has a negative effect in labor productivity once its effect through innovation expenditure or innovation output is taken into account. The results are very similar if we use only the 5th innovation survey (regressions 5-6) and we include the investment in new equipment. However this could be a reflection that the variable is not a good proxy for capital stock and in fact it is not significant in any specifications.

The predicted probability of introducing innovative products or processes is significant for both KIBS and traditional services, although it appears to be particularly relevant for the traditional services industries. The same appears to be true for Innovation expenditure

Overall, the CDM model *a la Crespi and Zuñiga* appears to be valid for both manufacturing and services. The coefficients in general have similar signs and level of

significance. The differences one can observe are mostly of coefficient sizes. Notwithstanding, one can observe differences between KIBS and traditional services, where variables are generally more important in KIBS in the first and second stages, but not so in the productivity equation.

6. Extensions

As an extension to the benchmark estimations of Crespi and Zuniga (2011) we provide estimations analyzing the differential impact of different obstacles to innovation, and we then assess the importance of skills and non-technological innovation, which according to the empirical literature have been identified as particularly relevant for the services sector.

a) Obstacles to innovation

We first provide similar estimations to the basic specification, but including measures of obstacles to innovation. We are particularly interested in the effect of financial restrictions on innovation expenditures. However, it is well known self-reported financial constraint has serious selection problems. To correct this problem, we follow the methodology applied by Savignac (2008) and Alvarez and Crespi (2011), and we use a predicted value of this variable to control for selection¹⁵. Since only ELE has questions on financial restrictions and information on balance sheet variables, we can only provide results for that survey which include this type of restriction. One of the questions in this Survey allows defining a direct measure of credit constraints for innovation. Firms are asked to identify the main two factors (from a specific list of eight closed and one open alternative) that are perceived as obstacle or disincentive to innovation. Similarly to Alvarez and Crespi (2011), we define a firm to be credit constrained if the alternative: “difficulty for obtaining adequate financing” is declared to be one of these two main obstacles.

An initial stage for estimating a predicted value for financial restrictions is shown in Table 11¹⁶. The variables included as determinants of credit constraints are financial variables (existence of collateral, debt to sales ratio, and distributed dividends), technological competitiveness (if the firm uses internet in different processes), human capital (of CEO and

¹⁵ We use the more restricted estimation in their paper, not considering firms that did not innovate and did not feel restricted by financial issues.

¹⁶ The ELE database contains close to 6200 observations. However, several variables used in the regressions have missing values. For this reason they are dropped from the estimation.

workers), and a set of dummy variables for firm size. The regression shows that the larger the firm the lower the probability of being financially constrained (omitted category are the smallest firms), the higher the human capital and age of the firm and CEO the lower the probability of being constrained, and having debt lowers the chance of declaring that you are constrained financially. Also unexpectedly, having collateral with fixed assets is correlated with a higher probability of being financially constrained, although this relationship is not statistically significant. Also using internet in different ways is also associated with this constrain.

Table 11: Probit regression of the probability of being financially constrained
(marginal effects shown)

VARIABLES	(1) FINANCIAL CONSTRAINT
Dependent Variable: Is your firm financial constrained?	
Collateral with fixed assets (dummy)	0.0265 (0.0335)
Ratio of debt to sales	-0.00243*** (0.000869)
% dividends distributed	-0.0688 (0.0434)
Firm Age	-0.000582 (0.000594)
CEO Age	-0.00347*** (0.000628)
CEO has tertiary education (dummy)	-0.0854*** (0.0174)
% of workers with tertiary education	-0.0243 (0.0252)
Firm has internet	0.117* (0.0686)
Firm has web page	0.00489 (0.0677)
Firm sells through internet	0.0953** (0.0480)
Firm buy through internet	0.0488 (0.0316)
Dummy size 2	-0.102*** (0.0169)
Dummy size 3	-0.173*** (0.0255)
Dummy size 4	-0.255*** (0.0192)
Observations	4,848

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 12 below shows the first stage of the Crespi and Zuniga (2011) with constraints to innovation for the ELE (specifications 1 and 2 provide the estimations with no restrictions as a comparison). Specifications 3 and 4 show that most constraints appear as not significant determinants of the amount spent in innovation (the coefficients in the services sector are actually opposite to what one could expect). Specifications 5 and 6 include our predicted probability of financial restrictions. Financial restrictions appear to be particularly important for services and show the opposite sign for manufactures although in this case is not significant, and easiness of imitation has the expected sign for manufactures (but still not significant). Finally, columns 7 and 8 exclude the firms that did not innovate and declared not

having any restrictions to innovate. In Alvarez and Crespi this exclusion implied a significant change of sign and magnitude of the coefficient of financial constraints. Unexpectedly, the coefficients here are almost exactly the same as columns 5 and 6. These dropped firms don't seem to have generated a bias in this case, but this is clearly counterintuitive.

In the Appendix we report two additional exercises, by including the financial constraints variable in the selection and then in the selection and intensity equations. Results on the intensity equation do not change, however when financial constraints enter only in the selection equation turn to have the opposite sign, meaning that those more constrained are those than have greater likelihood to invest in R&D.

Table 12: First stage with ELE and financial constraints

VARIABLES	(1)		(2)		(3)		(4)		(5)		(6)		(7)		(8)	
	Manufacturing	Services	Manufacturing	Services	Manufacturing	Services	Manufacturing	Services	Manufacturing	Services	Manufacturing	Services	Manufacturing	Services	Manufacturing	Services
Encuesta Longitudinal																
Dropping those not constraint																
Selection (prob of spending in innov)																
Exporting	0.0923*	0.157***	0.103*	0.118***	0.150**	0.0968***	0.194**	0.104***	(0.0524)	(0.0289)	(0.0614)	(0.0335)	(0.0668)	(0.0314)	(0.0769)	(0.0376)
Foreign	0.204***	0.0613*	0.150	0.00903	0.138	0.0258	0.330**	0.0358	(0.0773)	(0.0320)	(0.109)	(0.0333)	(0.114)	(0.0281)	(0.156)	(0.0373)
Size	0.123***	0.111***	0.103***	0.0899***	0.0729***	0.0529***	0.0805***	0.0623***	(0.0120)	(0.00428)	(0.0133)	(0.00419)	(0.0125)	(0.00320)	(0.0152)	(0.00427)
Intensity (log amount spend in innov per employee)																
Exporting	0.405*	0.167	0.558**	0.216	1.026**	0.112	1.033**	0.118	(0.210)	(0.140)	(0.255)	(0.208)	(0.417)	(0.282)	(0.418)	(0.283)
Foreign	0.271	0.727***	-0.0570	0.895***	-0.604	0.752**	-0.756	0.738**	(0.308)	(0.159)	(0.505)	(0.253)	(0.768)	(0.328)	(0.858)	(0.328)
Public financial support	-0.232	0.693**	-0.226	1.137***	-1.541*	0.775	-1.501*	0.765	(0.762)	(0.349)	(0.737)	(0.426)	(0.843)	(0.560)	(0.863)	(0.556)
High technical risk			-0.0553	0.111	-0.319	-0.0983	-0.310	-0.0991			(0.213)	(0.131)	(0.328)	(0.177)	(0.330)	(0.177)
Easiness of imitation			-0.0838	0.136	-0.927	0.323	-0.949	0.334			(0.644)	(0.353)	(0.779)	(0.307)	(0.787)	(0.308)
Financial Constraint					0.382	-3.889***	0.0983	-3.754***					(1.885)	(0.889)	(1.864)	(0.859)
Observations	966	5,854	774	4,669	606	3,932	508	2,936								

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

b) Skill intensity

As an additional extension we want to test whether some firm characteristics and output measures found to be relevant to services firms in the literature play a (differential) role in the case of Chile. One of them is skills, which seem to be more important for innovating and exporting (Iacovone et al (2012), Pires et al. (2008) and Eickelpasch and Vogel (2009)) in the service sector than in manufacturing.

We replicate first the original econometric specification but adding a measure of skill intensity in the innovation investment regression. We use the percentage of employees that have professional or technical education. This measure, however it is only available for the 6th innovation survey. The first stage of the CDM model can be seen in Table 13 (we show the results of estimations where skills appear in all equations). The results are similar than what we have previously observed. Skill intensity is significant in both the selection equation and the intensity equation. However, again the coefficient is larger for manufacturing than for services. When controlling for skills, size is also relevant for both types of firms, but the coefficient is also larger for manufacturing.

Table 13: Innovation selection and expenditure and role of skills

VARIABLES	(1)	(2)	(3)	(4)
	Manufacturing	Services	Traditional Serv	KIBS
6th Innovation survey 2007-2008				
<i>Selection (prob of spending in innov)</i>				
Exporting	0.0519 (0.0333)	0.0602* (0.0325)	0.0519 (0.0418)	0.0813 (0.0522)
Foreign	0.0193 (0.0449)	-0.0264 (0.0277)	-0.0261 (0.0374)	-0.0284 (0.0412)
Size	0.0848*** (0.0101)	0.0441*** (0.00405)	0.0421*** (0.00534)	0.0455*** (0.00663)
Patent Protection	0.405*** (0.102)	0.482*** (0.0895)	0.533*** (0.102)	0.422*** (0.155)
Skill intensity	0.217*** (0.0474)	0.0647** (0.0269)	-0.0127 (0.0385)	0.136*** (0.0387)
<i>Intensity (log amount spend in innov per employee)</i>				
Exporting	0.965*** (0.278)	0.218 (0.238)	-0.150 (0.315)	0.655* (0.364)
Foreign	0.565* (0.309)	0.131 (0.299)	0.423 (0.356)	-0.124 (0.461)
Public financial support	0.601 (0.433)	0.637* (0.326)	0.547 (0.446)	0.939* (0.550)
Patent Protection	0.240 (0.462)	0.593 (0.377)	0.513 (0.432)	0.543 (0.738)
Co-operation in R&D	0.711*** (0.249)	0.318* (0.176)	-0.0175 (0.205)	0.841*** (0.301)
Market info sources (INFO1)	0.926 (0.595)	-0.0831 (0.417)	0.101 (0.541)	-0.398 (0.669)
Scientific sources (INFO2)	-0.0708 (0.799)	0.258 (0.603)	0.635 (0.672)	-0.190 (0.939)
Other spillovers (INFO3)	0.369 (0.421)	0.197 (0.308)	0.0730 (0.421)	0.520 (0.451)
Skills intensity	1.103** (0.471)	0.998*** (0.267)	1.313*** (0.330)	0.657 (0.408)
Observations	1,265	2,627	1,543	1,084

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

When comparing KIBS and traditional services, skill intensity appears only to be significant in the selection equation for KIBS and only significant in the intensity equation for traditional services.

Table 14 shows the knowledge production function. As in the case of the use of the previous skill intensity variable, skills enters negatively and significant in this stage, which is counterintuitive, but may reflect the fact that skill is already entering through its effect on the expenditure on innovation.

Table 14: Knowledge production function

VARIABLES	(1)	(2)	(3)	(4)
	6th Innovation survey 2007-2008			
	Manufacturing	Services	Traditional Serv	KIBS
<i>Innovation output in product or process</i>				
IE_p (predicted Inn exp per employee)	1.226*** (0.245)	0.807*** (0.225)	0.500** (0.214)	0.630*** (0.102)
Size	0.0445*** (0.0135)	0.0293*** (0.00535)	0.0320*** (0.00647)	0.0338*** (0.00781)
Export (dummy)	-0.703*** (0.0849)	-0.261*** (0.0386)	-0.00611 (0.0511)	-0.313*** (0.0214)
Foreign Ownership (dummy)	-0.372*** (0.0475)	0.0148 (0.0320)	-0.139*** (0.0468)	0.222*** (0.0631)
Skills Intensity	-2.205*** (0.461)	-1.130*** (0.324)	-0.651** (0.268)	-0.882*** (0.162)
Observations	1,265	2,627	1,543	1,084

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

The coefficients are similar for traditional and KIBS subsectors, however being larger for KIBS (including a larger negative coefficient for skills).

Finally, we look at the output production function in Table 15. Skill intensity enters positively and significantly in both sectors, although its effect on labor productivity appears to be larger in services. This on top of a larger indirect effect through the predicted value of the probability of innovating which has also a larger coefficient for services.

Table 15: Output Production Function

Specification 1: using predicted probability of innovation output

VARIABLES	(1)	(2)	(3)	(4)
	6th Innovation survey 2007-2008			
	Manufacturing	Services	Traditional Serv	KIBS
<i>log labor productivity (sales per worker)</i>				
TI_p (Technological innovation)	0.734*** (0.141)	0.844*** (0.265)	1.230*** (0.443)	0.523** (0.225)
Size	0.0310 (0.0391)	-0.349*** (0.0195)	-0.340*** (0.0342)	-0.365*** (0.0275)
Skill intensity	0.635*** (0.158)	0.883*** (0.0961)	0.811*** (0.150)	0.963*** (0.135)
Constant	10.09*** (0.164)	11.15*** (0.139)	11.05*** (0.210)	11.31*** (0.146)
Observations	1,265	2,627	1,543	1,084
R-squared	0.052	0.267	0.284	0.243

Bootstrapped standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Specification 2: using predicted innovation expenditure per employee

VARIABLES				
<i>log labor productivity (sales per worker)</i>				
Size	-0.0716 (0.0468)	-0.327*** (0.0201)	-0.307*** (0.0303)	-0.356*** (0.0289)
IE_p (predicted Inn exp per employee)	-0.554** (0.227)	0.329** (0.162)	0.113 (0.312)	0.529** (0.211)
Skill intensity	0.588*** (0.0698)	0.383*** (0.0935)	0.507*** (0.172)	0.299*** (0.0987)
Constant	8.694*** (0.135)	10.37*** (0.257)	9.826*** (0.363)	10.61*** (0.288)
Observations	1,265	2,627	1,543	1,084
R-squared	0.127	0.269	0.287	0.247

Bootstrapped standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Summarizing, even though the recent empirical literature give a more important role to skills in the services sector, we do not find robust evidence of such a differential role. We find some cases in which skills appear as more significant in manufacturing and in other cases in services. Skills appear to be more relevant for KIBS when compared to traditional services, but not when compared to manufacturing.

c) Non-Technological Innovation

In a third and final extension, we will test specifications with non-technological innovation as dependent variable. In Crespi and Zúñiga (2011) this type of innovation only appears as explanatory variable in the productivity estimation. Non-technological innovation has been reported to be much more important in services than manufacturing (DTI (2007); Pires et al (2008)). We estimate the probability of introducing non-technological innovations as well as technological innovations and assess its importance in a labor productivity regression. Non technological innovation is defined as the probability of introducing marketing, design, distribution **or** management innovations.

We present results for the 2nd and 3rd stage of the CDM model, since the first stage is exactly the same as the base estimation of Table 8. Table 16 shows the estimation for the probability of introducing non-technological innovations and the impact of the expenditure in innovation as well as other covariates. It is an identical regression as Table 9, but where the dependent variable is non-technological innovation instead of technological innovation.

Table 16: Knowledge production function for non-technological innovation
(probit marginal effects shown)

	(1)	(2)	(3)	(4)
	5th and 6th Innovation Surveys 2005-2008			
VARIABLES	Manufacturing	Services	Traditional Serv	KIBS
<i>Non-technological innovation output</i>				
IE_p (predicted Inn exp per employee)	0.607*** (0.0551)	0.402*** (0.0423)	0.0725** (0.0342)	0.436*** (0.0472)
Size	0.0537*** (0.00730)	0.0342*** (0.00399)	0.0486*** (0.00493)	0.0234*** (0.00653)
Export (dummy)	-0.385*** (0.0323)	-0.182*** (0.0247)	0.0268 (0.0418)	-0.248*** (0.0277)
Foreign Ownership (dummy)	-0.189*** (0.0220)	-0.0879*** (0.0220)	-0.0455 (0.0349)	0.0629 (0.0438)
Observations	2,672	3,983	2,412	1,571

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Results are very similar to those of technological innovation in Table 9. The predicted value of innovation expenditure (which is mostly for technological purposes) has a strikingly similar impact in non-technological innovation, albeit a little smaller in the service sector. The (positive) impact of size and that of export status and foreign ownership (both negative) are also very similar to those of table 8. These very similar results might be due to the fact that technological and non-technological innovation appear to be very correlated.

When we disaggregate services between traditional and KIBS we again observe that the coefficient of innovation expenditure is larger for KIBS, although both coefficients are smaller when compared to the coefficients of the same variable on technological innovation. The opposite signs of foreign ownership remain for non-technological innovation, although they stop being significant.

To finalize, we show the output production function using the predicted probability of introducing non-technological innovations to analyze its impact on productivity. This can be seen in Table 17

Table 17: output production function for non-technological innovation

Specification 1: using predicted probability of non-tech innovation

whitout new equipment				
	(1)	(2)	(3)	(4)
5th and 6th Innnovation Surveys 2005-2008				
VARIABLES	Manufacturing	Services	Traditional Serv	KIBS
<i>log labor productivity (sales per worker)</i>				
TI_p (non-technological innovation)	1.281*** (0.176)	0.958*** (0.177)	7.989*** (1.062)	0.782*** (0.199)
Size	0.0186 (0.0280)	-0.329*** (0.0186)	-0.669*** (0.0575)	-0.351*** (0.0228)
Constant	10.09*** (0.0915)	12.90*** (0.121)	10.98*** (0.115)	11.57*** (0.110)
Observations	2,672	3,983	2,412	1,571
R-squared	0.038	0.198	0.243	0.141

Bootstrapped standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Results are again similar to Table 10 (using technological innovation), although the impact of non-technological innovation in productivity in services is larger than the effect of technological innovation. The opposite can be said for manufacturing (although the difference with Table 10 is minimal).

Appendix D, shows the estimations of a bivariate probit and a horseshoe between technological and non technological innovation. The insight we obtain is that technological innovation seems to be more important than non technological, which in turn appears with a puzzling negative sign. Moreover, technological innovation results more important for manufactures than services and within them, KIBS have a larger impact of technological innovation.

7. Conclusions

In this study we have performed an extensive analysis of innovation inputs, output, and impact in labor productivity of the services sector in Chile, while comparing it to manufacturing as a benchmark.

Using the 5th and 6th innovation surveys (2005-2008) we found that while being significantly less export oriented the services sector innovates as much as

manufacturing both in technological and non-technological types of innovation output, and for both sectors both types of innovation appear as important determinants of labor productivity. The variables analyzed as determinants for innovation inputs and outputs appear to be relevant in both sectors, with some variation across them. In particular, innovation output results to be more important for manufactures than services firms as engine of labor productivity. By the same token innovation expenditure results to be more important for manufactures than services as determinant of labor productivity. Firm size is a more significant determinant of innovation expenditure and the probability of producing a new product, service or process for manufacturing firms than service firms. Cooperation results to be more important as determinant of R&D expenditure for service firms than manufacturing firms, and within services KIBS benefit significantly more than traditional services. The former is a fact that has been corroborated in the case studies from Alvarez et al (2013).

We extend the work of Crespi and Zuñiga (2012) by investigating the impact of financial constraints and skilled labor on the innovation process. We find that financial constraints are irrelevant for manufactures, but very important for service firms as determinant of R&D expenditure. On the other hand, skills, which has been found to be a more important variable for services firms appears to be more important in manufacturing as determinant of the probability to spend in R&D. However, skills have greater impact in how much firms spend in traditional services than in manufactures. Maybe due to endogeneity problems we find that skills have a negative impact as determinant of innovation output. Nevertheless, skills level affect unambiguously positively labor productivity.

Overall even though we observe similar innovative behavior in both sectors, it might be the case that we are observing variables and outcomes more related to technological innovation which is well known to be more critical for manufacturing. What is interesting is that while playing on the manufacturing “field”, services firms show similar innovation intensities, determinants and impact of innovation on labor productivity. Also, these results might indicate that other variables, not measured in a traditional innovation survey, might be more relevant for the services industry, and that innovation surveys should maybe start incorporating a more clear-cut and less discrete non-technological view. In particular, we believe that moving innovation surveys questions on non-technological innovation along the 4D or 6D service innovation categories presented in Hertog (2010) could significantly improve our understanding on how

innovations are unfolded in the service sector.

The Chilean innovation surveys present some positive features that are valuable for our research. First, is a survey that has one of the largest time span coverage in Latin America. Second is a survey that has recently included the service sector in their sample. However, is a survey that shows a high level of aggregation regarding productive sectors, which are included just at a one digit level in the last survey that makes difficult in some cases identify specific subsectoral characteristics of the sample.

Appendix 1: Alternative estimations for robustness (Base scenario)

A. Base scenario estimations with weights

As a robustness check we provide the same original estimations of Tables 8-10 using the weights provided by the innovations surveys. Table A1 shows the selection and intensity regressions for the expenditure in innovation.

Table A1: First stage estimation of probability and intensity of innovation expenditure (using weights, marginal effects shown)

VARIABLES	(1)	(2)	(3)	(4)
	Manufacturing	Services	Traditional Serv	KIBS
5th and 6th Innovation Surveys 2005-2008				
<i>Selection (prob of spending in innov)</i>				
Exporting	0.0983*** (0.0332)	0.140 (0.128)	0.127 (0.146)	0.157* (0.0863)
Foreign	0.0285 (0.0426)	0.0157 (0.0965)	0.0246 (0.114)	-0.0207 (0.116)
Size	0.0864*** (0.0103)	0.0470*** (0.00956)	0.0358*** (0.00909)	0.0749*** (0.0165)
Patent Protection	0.334*** (0.0762)	0.0144 (0.133)	-0.00397 (0.147)	-0.00126 (0.0826)
<i>Intensity (log amount spend in innov per employee)</i>				
Exporting	0.679*** (0.182)	-0.206 (0.377)	-0.600* (0.352)	0.276 (0.447)
Foreign	0.323 (0.261)	0.528** (0.268)	0.541** (0.260)	0.140 (0.553)
Public financial support	0.272 (0.219)	1.432** (0.573)	0.863** (0.404)	1.382** (0.689)
Patent Protection	0.298 (0.356)	0.0359 (0.708)	-0.252 (0.547)	1.979** (0.857)
Co-operation in R&D	0.676*** (0.178)	0.0512 (0.290)	-0.341 (0.311)	1.230*** (0.473)
Market info sources (INFO1)	0.167 (0.203)	-0.353 (0.429)	-0.569 (0.366)	-0.268 (0.781)
Scientific sources (INFO2)	-0.0760 (0.134)	-0.0463 (0.242)	0.282 (0.261)	-0.590* (0.346)
Other spillovers (INFO3)	-0.0550 (0.177)	0.00259 (0.255)	-0.510** (0.241)	0.653 (0.578)
Observations	2679	3985	2,413	1,572

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Comparing Table A1 with Table 8, the most important differences can be appreciated in the service sector. In the selection equation, exporting and patent protection do not appear to be significant determinants of the probability of spending in innovation in the service sector, unlike Table 8. Moreover, in the intensity equation exporting becomes non-significant too and changes sign; foreign participation becomes significant and increases its coefficient, indicating that foreign capital shows an effect in the extent of expenditure more than in the probability of spending. Public support becomes 3 times as important as in the unweighted regression and patent protection and cooperation lose their significance. The results for the manufacturing sector do not change significantly. When disaggregating between KIBS and traditional services, patent protection again loses its significance in both and moreover changes sign and becomes negative. In the intensity equation, the loss of significance of exporting seems driven by traditional services, which now show a negative and marginally significant (at 10% level) coefficient. The significance of the coefficient of foreign capital again seems driven by the traditional services, which is now significant and was not in the version without weights. Patent protection loses significance because of netting of a negative coefficient (although not significant) for traditional services and a large positive and significant coefficient for KIBS. Patent protection here appear very relevant for the KIBS sector to increase the expenditure in innovation. Something similar can be observed for cooperation in R&D. The coefficient with weights losses significance in services because the coefficient for the traditional services sector changes sign and becomes negative (and not significant), whereas the KIBS sector shows a highly positive and significant coefficient.

Overall, these differing results with the unweighted regressions suggest we should be careful with the conclusions taken with part of the variables analyzed in the main text, particularly regarding the Services sector.

Second, we show the knowledge production function in Table A2.

Table A2: 2nd stage estimation: Probability of innovating in products, services or processes (probit marginal effects shown, using weights)

VARIABLES	(1)	(2)	(3)	(4)
	5th and 6th Innovation Surveys 2005-2008			
	Manufacturing	Services	Traditional Serv	KIBS
<i>Innovation output in product or process</i>				
IE_p (predicted Inn exp per employee)	0.505*** (0.0605)	-0.252** (0.124)	-0.600*** (0.115)	0.206*** (0.0529)
Size	0.0600*** (0.0108)	0.0347*** (0.0123)	0.0209 (0.0144)	0.0547*** (0.0158)
Export (dummy)	-0.335*** (0.0394)	0.382* (0.195)	0.285 (0.190)	-0.125** (0.0522)
Foreign Ownership (dummy)	-0.163*** (0.0310)	0.210 (0.181)	0.566*** (0.181)	-0.00103 (0.0980)
Observations	2,679	3,985	2,413	1,572

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The second stage also shows robustness for the results for manufacturing in table 9, but different results for the services sector, mostly apparently driven by different coefficients from the traditional services sector.

Finally, Table A3 compares the production function with that of table 10.

Table A3: Production Function

Specification 1: using predicted probability of innovation output

VARIABLES	whitout new equipment			
	(1)	(2)	(3)	(4)
	5th and 6th Innovation Surveys 2005-2008			
	Manufacturing	Services	Traditional Serv	KIBS
<i>log labor productivity (sales per worker)</i>				
TI_p (Technological innovation)	1.314*** (0.147)	1.544*** (0.379)	0.0477 (0.127)	1.305*** (0.238)
Size	-0.00758 (0.0356)	-0.352*** (0.0213)	-0.265*** (0.0194)	-0.420*** (0.0349)
New Equipment				
Constant	10.17*** (0.115)	12.75*** (0.173)	10.94*** (0.110)	11.57*** (0.105)
Observations	2,679	3,985	2,413	1,572
R-squared	0.048	0.197	0.228	0.148

Bootstrapped standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

We show only specification 1 and without the new equipment. Again, results are similar as the base estimation for manufacturing. Interestingly, also the coefficients for the service sector are not altered much when we use weights. However, again for the traditional services subsector the coefficient for the predicted value of the probability of innovating decreases dramatically and becomes insignificant.

B. Base scenario estimations using 4th-7th pooled innovation surveys

As a second robustness check on the results we add the base model (and we disaggregate for KIBS and non-KIBS subindustries) using the 4 datasets on innovation surveys we have available. Table B1 shows the results of the first stage.

Table B1: Innovation investment selection and intensity equation, 4th-7th innovation surveys

VARIABLES	unweighted				weighted			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
	4th, 5th, 6th and 7th Inn Surveys 2003-2010				4th, 5th, 6th and 7th Inn Surveys 2003-2010			
	Manufacturing	Services	Traditional Serv	KIBS	Manufacturing	Services	Traditional Serv	KIBS
<i>Selection (prob of spending in innov)</i>								
Exporting	0.118*** (0.0164)	0.0859*** (0.0210)	0.0831*** (0.0285)	0.0942*** (0.0308)	0.123*** (0.0230)	0.0300 (0.0571)	0.0281 (0.0718)	0.0797 (0.0656)
Foreign	0.0885*** (0.0156)	0.0197 (0.0130)	-0.00955 (0.0176)	0.0343* (0.0194)	0.0642*** (0.0234)	-0.00780 (0.0344)	-0.0279 (0.0484)	0.00636 (0.0364)
Size	0.0877*** (0.00498)	0.0583*** (0.00235)	0.0518*** (0.00321)	0.0615*** (0.00355)	0.0790*** (0.00703)	0.0418*** (0.00572)	0.0318*** (0.00609)	0.0607*** (0.00873)
Patent Protection	-0.0637*** (0.0163)	-0.0221** (0.0111)	-0.00204 (0.0158)	-0.0493*** (0.0169)	-0.0228 (0.0253)	-0.0654*** (0.0247)	-0.0528 (0.0347)	-0.0917*** (0.0305)
<i>Intensity (log amount spend in innov per employee)</i>								
Exporting	0.458*** (0.104)	0.455*** (0.155)	0.387* (0.217)	0.484** (0.222)	0.565*** (0.142)	0.207 (0.394)	-0.295 (0.442)	0.197 (0.610)
Foreign	0.188* (0.101)	0.0432 (0.111)	-0.0512 (0.158)	0.0861 (0.162)	-0.0869 (0.164)	0.0932 (0.248)	0.00960 (0.262)	-0.0963 (0.341)
Public financial support	0.329** (0.138)	0.154 (0.163)	-0.196 (0.232)	0.565** (0.238)	0.0977 (0.250)	0.749** (0.379)	0.250 (0.454)	1.231** (0.570)
Patent Protection	0.102 (0.121)	-0.0819 (0.101)	-0.174 (0.152)	-0.0137 (0.153)	-0.321* (0.184)	0.0714 (0.208)	-0.196 (0.257)	0.271 (0.323)
Co-operation in R&D	0.455*** (0.105)	0.664*** (0.0956)	0.308** (0.148)	0.898*** (0.136)	0.602*** (0.167)	0.0949 (0.259)	-0.642** (0.253)	1.319*** (0.319)
Market info sources (INFO1)	-0.0595 (0.138)	0.0298 (0.139)	0.0118 (0.208)	-0.0824 (0.201)	0.120 (0.217)	-0.606* (0.349)	-0.375 (0.343)	-0.923* (0.544)
Scientific sources (INFO2)	0.0279 (0.0888)	-0.130 (0.0886)	-0.118 (0.145)	-0.113 (0.116)	-0.114 (0.138)	0.218 (0.196)	0.115 (0.246)	0.131 (0.298)
Other spillovers (INFO3)	-0.0530 (0.126)	-0.000314 (0.110)	-0.0438 (0.165)	0.0796 (0.155)	-0.0345 (0.172)	-0.400* (0.227)	-0.709*** (0.273)	-0.105 (0.383)
Observations	4,928	7,689	3,765	3,443	5,005	7,689	3,765	3,443

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Comparing first the unweighted databases, we find that results are very similar with the base scenario in the main text. The only difference being the impact of patent protection on the decision to spend, which with the 4 innovation surveys together changes sign and becomes negative and significant, something which is counterintuitive. When disaggregating the

services industries in KIBS and traditional services, we again observe differences in the traditional services sector, where exporting becomes a significant correlate of the probability of investing in innovation, and where patent protection loses significance and actually changes sign, becoming negative. Differences in the intensity equation are minimal.

Now we look at the weighted pooled cross section. As in the case of the weighted pool of the 5th and 6th surveys, when adding the 4th and 7th, we also observe that exporting becomes insignificant in explaining the probability of spending on innovation. Foreign participation is now only significant in manufacturing (it was not significant in neither the base estimation and in the weighted 5th and 6th). Here too patent protection change sign and become significant in the case of services, consistent with what happened with the unweighted 4th-7th pool. For the intensity specification, again for services we observe relevance for public financial support, as in the original model and the its weighted version. Market information sources and other spillovers become negative when comparing with the original model and are now significant at the 10% level. Overall we observe that except for the role of patent protection, manufacturing innovation expenditure determinants found in the base model appear to be robust to the use of weights and different databases. In the case of services, the most robust determinants of the decision and extent of innovation expenditure are size and public financial support. Significant determinants, such as exporting, patent protection and cooperation for R&D are sensitive to the use of weights or the inclusion of older or newer data.

Finally, looking at KIBS and traditional services, adding the 4th and 7th survey with weights generates similar results to the weighted version of the 5th and 6th surveys, indicating the same potential weaknesses of the results found in the base estimations.

Appendix C: Alternative specification for the Financial Constraint in ELE

Table C1: First stage estimation of probability and intensity of innovation expenditure. Financial Constraints as determinant of the decision to invest in R&D.

Adding Financial Constraint in the 1st step				
VARIABLES	(1)	(2)	(3)	(4)
	Encuesta Longitudinal		Dropping those not constraint	
	Manufacturing	Services	Manufacturing	Services
<i>Selection (prob of spending in innov)</i>				
Exporting	0.266*** (0.0917)	0.0943 (0.0585)	0.266*** (0.0917)	0.0943 (0.0585)
Foreign	0.487*** (0.0354)	0.0854 (0.0722)	0.487*** (0.0354)	0.0854 (0.0722)
Size	0.133*** (0.0276)	0.132*** (0.0104)	0.133*** (0.0276)	0.132*** (0.0104)
High technical risk	-0.0503 (0.0742)	0.0357 (0.0347)	-0.0503 (0.0742)	0.0357 (0.0347)
Easiness of imitation	0.264 (0.179)	-0.00888 (0.0713)	0.264 (0.179)	-0.00888 (0.0713)
Financial Constraint	0.502 (0.331)	0.368** (0.167)	0.502 (0.331)	0.368** (0.167)
<i>Intensity (log amount spend in innov per employee)</i>				
Exporting	0.944** (0.369)	0.291 (0.283)	0.944** (0.369)	0.291 (0.283)
Foreign	-1.195 (0.878)	0.873*** (0.328)	-1.195 (0.878)	0.873*** (0.328)
Public financial support	-1.621* (0.949)	0.830 (0.594)	-1.621* (0.949)	0.830 (0.594)
Observations	277	1,489	277	1,489

Robust standard errors in parentheses
 *** p<0.01, ** p<0.05, * p<0.1

Table C2: First stage estimation of probability and intensity of innovation expenditure. Financial Constraints as determinant of the decision to invest and level of R&D expenditure.

Adding Financial Constraint in both steps

VARIABLES	Encuesta Longitudinal			
	(1)	(2)	(3)	(4)
	Manufacturing	Services	Manufacturing	Services
<i>Selection (prob of spending)</i>				
Exporting	0.271*** (0.0919)	0.0863 (0.0587)	0.271*** (0.0919)	0.0863 (0.0587)
Foreign	0.487*** (0.0355)	0.0863 (0.0723)	0.487*** (0.0355)	0.0863 (0.0723)
Size	0.136*** (0.0282)	0.130*** (0.0103)	0.136*** (0.0282)	0.130*** (0.0103)
High technical risk	-0.0774 (0.0790)	0.0323 (0.0351)	-0.0774 (0.0790)	0.0323 (0.0351)
Easiness of imitation	0.235 (0.214)	0.00105 (0.0744)	0.235 (0.214)	0.00105 (0.0744)
Financial Constraint	0.552 (0.377)	0.205 (0.159)	0.552 (0.377)	0.205 (0.159)
<i>Intensity (log amount spend in innov per employee)</i>				
Exporting	1.075** (0.424)	0.141 (0.286)	1.075** (0.424)	0.141 (0.286)
Foreign	-1.147 (0.878)	0.659** (0.331)	-1.147 (0.878)	0.659** (0.331)
Public financial support	-1.566* (0.893)	0.743 (0.547)	-1.566* (0.893)	0.743 (0.547)
High technical risk	-0.282 (0.330)	-0.111 (0.177)	-0.282 (0.330)	-0.111 (0.177)
Easiness of imitation	-1.086 (0.850)	0.321 (0.309)	-1.086 (0.850)	0.321 (0.309)
Financial Constraint	-0.348 (1.657)	-3.959*** (0.839)	-0.348 (1.657)	-3.959*** (0.839)
Observations	277	1,489	277	1,489

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table C3: 2nd stage estimation: Probability of innovating in products, services or processes

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Manuf	Serv	Manuf	Serv	Manuf	Serv	Manuf	Serv
	Adding Financial Contrain in the 1st step				Adding Financial Contrain in both steps		Dropping those not constraint	
	Dropping those not constraint							
IE_p (predicted Inn exp per employee)	-0.250*	0.168*	-0.184	0.202	0.0465	-0.0432	0.0465	-0.0432
	(0.134)	(0.0991)	(0.136)	(0.132)	(0.110)	(0.0394)	(0.110)	(0.0394)
Size	0.0819***	0.0716***	0.0835***	0.0817***	0.113***	0.0890***	0.113***	0.0890***
	(0.0109)	(0.00335)	(0.0119)	(0.00435)	(0.0217)	(0.00876)	(0.0217)	(0.00876)
Export (dummy)	0.366**	-0.0135	0.297*	-0.0304	-0.0543	0.0371	-0.0543	0.0371
	(0.162)	(0.0469)	(0.157)	(0.0619)	(0.182)	(0.0557)	(0.182)	(0.0557)
Foreign Ownership (dummy)	0.0357	-0.0900	0.150*	-0.0754	0.366**	0.146*	0.366**	0.146*
	(0.0830)	(0.0823)	(0.0907)	(0.125)	(0.168)	(0.0804)	(0.168)	(0.0804)
Observations	966	5,854	807	4,337	277	1,489	277	1,489

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table C4: Production Function

Specification 1: using predicted probability of innovation output								
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Manufacturing Services Adding Financial Constraint in the 1st step		Manufacturing Services Dropping those not constraint		Manufacturing Services Adding Financial Constraint in both steps		Manufacturing Services Dropping those not constraint	
<i>Innovation output in product or process</i>								
Size	0.212*** (0.0251)	0.0607*** (0.0101)	0.219*** (0.0273)	0.0840*** (0.0126)	0.271*** (0.0424)	-0.0735** (0.0287)	0.271*** (0.0425)	-0.0735*** (0.0246)
IE_p (predicted Inn exp per employee)	0.539*** (0.0804)	1.078*** (0.0657)	0.502*** (0.0889)	1.092*** (0.0820)	0.282** (0.113)	1.524*** (0.103)	0.282** (0.127)	1.524*** (0.0972)
Constant	6.093*** (0.462)	2.162*** (0.518)	6.283*** (0.528)	2.007*** (0.626)	7.379*** (0.673)	2.098*** (0.447)	7.379*** (0.749)	2.098*** (0.436)
Observations	966	5,851	807	4,334	277	1,489	277	1,489
R-squared	0.201	0.176	0.204	0.192	0.218	0.322	0.218	0.322
Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1								
Specification 2: using predicted innovation expenditure per employee								
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Manufacturing Services Adding Financial Constraint in the 1st step		Manufacturing Services Dropping those not constraint		Manufacturing Services Adding Financial Constraint in both steps		Manufacturing Services Dropping those not constraint	
TI_p (Technological innovation)	6.187*** (1.267)	6.157*** (0.620)	5.848*** (0.879)	7.548*** (0.652)	3.899*** (1.287)	-3.259** (1.646)	3.899*** (1.118)	-3.259** (1.336)
Size	-0.256** (0.111)	-0.366*** (0.0474)	-0.252*** (0.0837)	-0.493*** (0.0556)	-0.112 (0.145)	0.442*** (0.132)	-0.112 (0.125)	0.442*** (0.109)
Constant	8.019*** (0.262)	9.381*** (0.141)	7.655*** (0.240)	8.691*** (0.198)	8.457*** (0.236)	11.09*** (0.375)	8.457*** (0.200)	11.09*** (0.331)
Observations	966	5,851	807	4,334	277	1,489	277	1,489
R-squared	0.199	0.158	0.217	0.186	0.231	0.159	0.231	0.159
Bootstrapped standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1								

Appendix D

Table D1: Knowledge production function for technological and non-technological innovation (biprobit marginal effects shown)

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	5th and 6th Innovation Surveys 2005-2008							
	Manufacturing		Services		Traditional Services		Kibs	
	Technological	Non-Technological	Technological	Non-Technological	Technological	Non-Technological	Technological	Non-Technological
IE_p (predicted Inn ex	0.557*** (0.0461)	0.506*** (0.0449)	0.420*** (0.0352)	0.389*** (0.0396)	0.244*** (0.0357)	0.173*** (0.0348)	0.424*** (0.0386)	0.380*** (0.0407)
Size	0.0748*** (0.00799)	0.0534*** (0.00713)	0.0354*** (0.00403)	0.0325*** (0.00405)	0.0438*** (0.00496)	0.0446*** (0.00491)	0.0339*** (0.00659)	0.0256*** (0.00670)
Export (dummy)	-0.363*** (0.0309)	-0.326*** (0.0305)	-0.218*** (0.0202)	-0.189*** (0.0244)	-0.0698* (0.0368)	-0.0315 (0.0395)	-0.274*** (0.0252)	-0.220*** (0.0313)
Foreign Ownership (d	-0.186*** (0.0254)	-0.172*** (0.0229)	-0.0679*** (0.0235)	-0.0944*** (0.0216)	-0.123*** (0.0306)	-0.0984*** (0.0311)	0.122*** (0.0432)	0.0330 (0.0418)
Observations	2,688	2,688	4,023	4,023	2,421	2,421	1,602	1,602
Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1								

Table D2: Output production function for technological and non-technological innovation (using

predicted marginal effects of biprobit)

VARIABLES	(1)	(2)	(3)	(4)
	Manufacturing	Services	Traditional Serv	KIBS
5th and 6th Innovation Surveys 2005-2008				
<i>log labor productivity (sales per worke</i>				
TI_p1 (Technological innovation)	35.09*** (4.349)	8.217*** (1.840)	1.939 (2.524)	3.665** (1.674)
TI_p2 (Non-Technological innovation)	-65.25*** (7.059)	-11.30*** (2.353)	-13.71*** (3.162)	-3.268 (2.883)
Size	-0.518*** (0.0927)	-0.303*** (0.0164)	-0.201*** (0.0333)	-0.350*** (0.0287)
Constant	12.90*** (0.354)	10.99*** (0.132)	13.59*** (0.367)	11.62*** (0.178)
Observations	2,688	4,023	2,421	1,602
R-squared	0.079	0.200	0.235	0.135

Robust standard errors in parentheses
 *** p<0.01, ** p<0.05, * p<0.1

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