Inter-American Development Bank

Competitiveness and Innovation Division (IFD/CTI)

DISCUSSION PAPER

No. IDB-DP-264

Technological and Non-technological Innovation and Productivity in Services vis a vis Manufacturing in Uruguay

Diego Aboal
Paula Garda

December 2012

Technological and Non-technological Innovation and Productivity in Services vis a vis Manufacturing in Uruguay

Diego Aboal
Paula Garda

Inter-American Development Bank
2012

http://www.iadb.org

Diego Aboal: aboal@cinve.org.uy; Paula Garda: pgarda@cinve.org.uy

Abstract[*]

In this paper, the links between the investment in innovation activities, innovation outputs (technological and non-technological innovation), and productivity in services and manufacturing are explored using innovation survey data from Uruguay. This is the first attempt to study these links for a developing country. The size of firms, their cooperation on R&D activities, the use of public financial support, patent protection, and the use of market sources of information, are the variables that are more consistently associated with the decision to invest in innovation activities across sectors. The main determinants of technological and non-technological innovations are the level of investment in innovation activities and the size of firms. The results indicate that both technological (i.e., product and process) and non-technological (i.e., marketing an organizational) innovations are positively associated to productivity gains in services, but non-technological innovations have a more important role. The reverse happens for manufacturing; technological innovations are the relevant ones for productivity.

JEL classifications: O12, O14, O31, O33, O40
Key words: Innovation, Productivity, Services, Manufacturing, Developing countries, Latin America, Innovation surveys

[*] We thank the comments and suggestions by Gustavo Crespi and participants of the second workshop of the research project Innovation and Productivity in Services of the IDB, IDRC and CINVE that took place in Lima, Peru, in November 2012.

1. Introduction

The service sector is increasingly important not only in developed economies (OECD, 2010; European Commission, 2009), but also in developing ones. On average, in Latin America and the Caribbean (LAC), the service sector accounts for more than 60 percent of both GDP and total employment (World Development Indicators, 2011). While the share of the service sector has been increasing, its rate of productivity growth has remained stubbornly low, particularly among small and medium enterprises (SMEs), when compared to other sectors of the economy. Consequently, it has pulled down the region's aggregate productivity levels (IDB, 2010). Thus, boosting innovation in services, especially in SMEs, is central to improving the performance of this sector, and the economy as a whole.

The service sector can impact the whole economy through its capacity to affect a country's efficiency and technological frontier. First, traditional services, such as transport, logistics, and wholesale trade, are the links between the different production blocks of the economy; hence, an increase in the productivity of these sectors will improve productivity in the production of final goods as well. Second, knowledge-intensive business services (KIBS), such as software and engineering services, can strengthen the innovative capacity of the whole economy, improving country's long-run growth potential (Europe Innova, 2011; Sissons, 2011; OECD, 2001). Finally, manufacturing and services are becoming increasingly integrated; therefore from a value chain (or value system) perspective, the competitiveness of the manufacturing sector, for instance, depends to a great extent on the efficiency and value added in the production of services.

In this respect, services are increasingly considered to be fundamental inputs and outputs of innovation processes in the other sectors of the economy (Kuusisto, 2008a). This contrasts with the traditional view in which service sectors are considered "innovation averse," thus "uninteresting" for innovation policies (and policymakers) (Baumol, 1967; Pavitt, 1984). Indeed, Baumol (1967) put forward the hypothesis that productivity improvements in service sectors are less likely than in the goods-producing sectors of the economy "because of the inherent nature of services". On the other hand, Pavitt (1984) suggested that from an innovation point of view, services are a "supplier dominated" sector in the sense that, in the best case, they merely adopt innovations carried out elsewhere in the economy, with only minor adaptations. As a consequence of these traditional views on the service economy, national innovation policies have paid limited attention to services, and service-sector firms have been systematically neglected in government-sponsored innovation programs.

Recently, these traditional views are being challenged by researchers in developed countries suggesting that services are more innovative than previously thought and that in some subsectors (e.g. KIBS) they are even more innovative than the goods-producing sectors of the economy (Evangelista and Savona, 2003; Bogliacino, Lucchese, and Pianta, 2007). The same researchers, however, find that several characteristics of innovation in firms in the service sector differ from firms in the goods-producing sectors (typically in the manufacturing sector). First, most innovations in services appear to be non-technical and the result of small, incremental changes in processes and procedures that do not require much formal research and development (R&D). Therefore, innovation seems to have an "ad-hoc" nature and to be a continuous process, complicating the identification of innovations as single events. Second, services make greater use of trademarks, designs, and copyrights to protect their innovations (they use a different set of rights than manufacturing). Thus, in terms of innovation inputs, it seems that ICT capital, software, training, marketing investments, and knowledge acquisition are more important for innovation in services than in other sectors of the economy (Uppenber and Strauss, 2010; Hertog, 2010). Thus, the traditional view that services are less innovative than the goods-producing sectors of the economy could be explained by the difficulty of identifying service innovations as single events in which R&D expenditures are less critical inputs. The arrival of innovation surveys, first in developed countries, and later in developing countries, has helped to dramatically challenge this view.

In terms of motivation for innovate, evidence from OECD countries also suggests that service-sector firms innovate for many of the same reasons that manufacturing firms do: to increase market share, to improve service quality, and to expand product or service range (OECD, 2005). However, it is also clear that "one-size-fits-all" theories on innovation in services are misleading to the extent that services are a diverse group of sectors with regard to both production and innovation (Tether, 2004). Additionally, and of fundamental importance for the region, although evidence for developed countries seems to suggest that large service sector firms are also more innovative than small firms, the correlation between size and innovation (the size premium) is weaker in services than in manufacturing. This, in principle, points to a higher potential for SME-driven innovation in services.

Despite the increasing interest in understanding and promoting innovation in the service sector in developed countries (Galluj and Djellal, 2010; Gallouj and Savona, 2008; Europe Innova, 2011; Kuusisto, 2008a; OECD, 2005, 2009a,b, 2010; Uppenberg and Strauss, 2010; Rubalcaba and Gago, 2006; Cainelli et al., 2006), there is far less research and no systematic studies on how to promote innovation and productivity growth in services in LAC (Tacsir, 2011). Developing policies and programs to support service-sector innovation requires a better understanding of this process. This paper aims to fill some of these gaps by expanding our knowledge and understanding of key focus areas related to the process of innovation and its impacts on productivity in the service sector in one LAC country, Uruguay.

First, one of the primary focuses of this research is determining the drivers of innovation and productivity in market services, with special emphasis on obstacles and the role of public policy. Taking as a given that business practices related to innovation are different in service sectors than in goods-producing activities, proper support and encouragement for innovation and productivity growth in the service sector may necessitate new policy designs and programs. This justifies the comparative perspective, with respect to the manufacturing sector, that this paper has.

Second, we will place particular emphasis on small firms. This is justified not only by the importance of small firms in the service sector (Tacsir, 2011) but also because large firms are in a better position to carry out research and innovate with little external support. Among the advantages cited for large firms are a larger spread of fixed costs over greater output, economies of scope, and better appropriation of external knowledge spillovers (Cohen and Levinthal, 1989; Crespi and Zuñiga, 2010). In addition, small firms have different characteristics and needs that justify a special focus on them. There is evidence that technologies developed for large service companies do not serve the small firms' needs well; small firms are less prone to innovate and they innovate differently: instead of R&D activities they follow different strategies that combine organizational innovation, purchase of equipment and learning through interaction with clients, and they also face different competitive challenges (European Commission, 2010).

Third, we will analyze both KIBS and traditional services and will compare them with the high and low tech manufacturing sectors. Even though traditional services tend to be less innovative than KIBS, this is a very important subsector to be analyzed, not only because of its weight in terms of value added and employment, but also because some of the most vulnerable workers (female, young, less educated, less formalized workers) are employed there. Therefore the understanding of how innovation and productivity gains happen on this sector can have potential impact on the design of more focused innovation policies with a better positive impact on productivity and labor market and social indicators. With these objectives we will use a modified version of the model of Crepon, Duguet, and Mairesse (1998) (CDM model) and Uruguayan data. As far as we know this is the first microeconometric analysis of the links between innovation activities, innovation and productivity in services for a development country.

In what follows, in Section 2 a brief review of the literature is presented. In Section 3 we describe the data to be used. Section 4 is devoted to the description of the empirical strategy to follow. Section 5 presents the results for the basic model at an aggregate level for services and manufacturing. Section 6 explores heterogeneities among different types of services and manufacturing firms: traditional, KIBS and small service firms, and low-tech, high-tech and small manufacturing firms. Section 7 analyzes two extensions to the basic model, the introduction of obstacles to innovate in the first stage of the model and role of the level of skills of the workforce for innovation and productivity. Finally in section 8 we conclude.

2. Literature Review

There are only a few studies assessing empirically the relation between innovation and productivity in service sector using firm level data, and even fewer comparing services and manufacturing. As far as we know, so far, all of the available evidence is for European or OECD countries.

Cainelli, Evangelista y Savona (2006) explores the two-way relationship between innovation (different proxies are used) and economic performance (labor productivity, measured as sales per worker, is one of the indicators) in services at the firm level. They use longitudinal firm level data for Italy (735 service firms with 20 or more employees), that are obtained from the matching of the Italian Community Innovation Survey (CIS) II data (1993–95) and a set of economic variables from the Italian System of the Enterprise Accounts (1993–98). Heckit models are used to estimate the impact of innovation on productivity and vice versa, and exploit the different timing of the variables to deal with endogeneity issues. Their main results are: (i) innovation activities undertaken in 1995 do have a positive impact on productivity levels in the following three years, (ii) better performing firms are more prone to innovate as well as to devote more resources to innovation, (iii) estimates reveal the presence of a cumulative mechanism which dynamically links productivity and total innovation expenditure per employee.

Loof (2004) brings a comparative perspective into the relationship between innovation and productivity in manufacturing and services. He investigate whether there is any evidence for the notion that service industries have a lower propensity to be innovative or whether they are less efficient in deriving benefits from innovations. Matched firm level data from Sweden CIS 1999 and data collected from Statistics Sweden are used in the empirical exercise. A version of the CDM model is fitted for two samples of knowledge intensive firms are used: 607 knowledge-manufacturing firms (with high degree of R&D intensity), and 538 business service firms. The labor productivity is measured as value added per employee (labor productivity) and innovation is proxied by the ratio of innovation sales to total sales. Loof finds a consistent positive relationship between R&D, innovation and productivity for both samples of firms. The estimated coefficients are similar for both samples.

Mairesse and Robin (2010) analyze the link between innovation and productivity using CIS data for French Manufacturing and Services. They study the evolution of the innovation – productivity relationship in the French manufacturing industry over two periods of time (1998-2000 and 2002-2004) and compare this relationship in the manufacturing and services industries in the period 2002-2004. The service sample comprises 3599 firms from CIS4 (with 20 or more employees), and the manufacturing one, a sample of 3524 firms from CIS3 and a sample of 4955 firms from CIS4. They estimate a version of the CDM model. They use the (log of) labor productivity (measured as the ratio of value-added to the number of employees) as the main independent variable, and indicators of product and process innovation, for proxies of innovation.They find a significant effect of product innovation on productivity and no effect (or little effect) of process innovation. This result is consistent across both periods and for both manufacturing and services. Being a product innovator results in a 17% increase in the log of labor productivity (with a standard deviation of 3 percent). This increase is stronger in services than in the manufacturing sample (13 percent), which suggests that product innovation results in a greater differentiation between services firms.

Lopes and Godinho (2005) analyze the link between innovation and labor productivity in services with a CDM model and using the second Portuguese CIS (1995–1997) that have 1014 observations. They find a positive effect of innovation output on productivity, but a negative effect of innovation intensity.

Stelios and Aristotelis (2008) explore the relationship between innovation output (sales from innovations per employee) and productivity (sales per employee) in the service sector in Greece. They use data from the CIS 2 (1994–1997) for Greece; 301 observations. They conclude that an increase in the innovation output leads to an improvement in productivity, both for the whole sample and for KIS.

Masso and Vahter (2012) using a version of the CDM model and CIS data for Estonia for the period 2002-2004 (604 firms) and 2004–2006 (687 firms) find that innovation is associated with increased productivity (log sales per employee and log value added per employee) in the service sector, and that the effect is stronger in the less knowledge intensive firms. Non-technological innovations (marketing and organizational) play less important role than technological innovations (product and process). Criscuolo (2009) in a large-scale study based on the CDM approach and CIS data, shows that for most countries (8 out of 10) the productivity effect of product innovation was larger in the manufacturing sector than in services.

Mansury and Love (2008) using data from a survey of 206 U.S. business services and a Heckman model find that service innovation has a positive effect on sales growth, but not on productivity. There is much more evidence at firm level for the manufacturing sector. For a recent review of this literature see Hall (2011). This survey finds that the evidence on the (positive) impact of product innovation on revenue productivity is strong but the impact of process innovation is somewhat ambiguous (in sign and significance).

3. Data and Descriptive Statistics

The service sector is one of the major contributors to output and employment in Uruguay. In the period 2004–2009 it has represented approximately 60 percent of the GDP of the economy and employed more than 70 percent of the total workforce. During this period of intense dynamism of the economy (which has grown at an annual rate of 6.2 percent), the rate of growth of the sector has been even higher (average annual growth rate of 7 percent).

Both, the employment and the output of the service sector are concentrated in a few subsectors. Half the GDP of the sector is explained by three subsectors: “Retail”, “Communications”, and “Real Estate, Renting and Business Services”. The same applies to employment, two sectors accounts for 50% of total employment in services: “Retail” and “Professional Services and Household's Services”.

Innovation surveys in Uruguay do not cover the universe of the service sector. However, the weight of the subsectors considered here is significant in terms of output and employment, representing more than 50 percent of the output and 33 percent of the employment of the sector (see Table 1).

Table 1. Contribution of the Service Sector to GDP and Employment in Uruguay *(average years 2005–2009)*

	GDP	Employment
Service sector/total economy	**59.2**	**73.5**
Subsectors as % of service sector		
Electricity, gas and water *	3.5	1.2
Retail	18.7	27.6
Hotels and restaurants *	4.6	3.9
Transport and Communication *	12.9	8.1
Financial intermediation	7.9	2.4
Real estate, renting and business *	23.4	9.7
Public administraton and defense	8.5	9.7
Education	6.3	8.1
Activities related to human health *	8.1	10
Professional services and domestic household serv.	6.1	19.2
Sectors covered by SIS(a)/Total service sector	52.5	33

* Included in innovation surveys; (a) Including real state

Source: INE, BCU.

The subsectors covered by the innovation surveys in Uruguay are the following (ISIC Rev.3): "Electricity, Gas, Steam and Hot Water"; "Collection, Purification and Distribution of Water", "Hotels and Restaurants", "Land Transport", "Water Transport", "Air Transport", "Auxiliary Transport Activities and Travel Agencies", "Post and Telecommunications", "Rental of Machinery Equipment, Personal Effects and Household Goods", "Informatics and Related Activities", "Research and Development", "Business Services", and "Activities Related to Human Health".

These subsectors were chosen by ANII following two criteria. First, that knowledge-intensive services were well represented in the sample, in particular the high technology ones (such as "Informatics and Related Activities", and "Research and Development"), the knowledge-intensive market services ("Air Transport", "Water Transport"; "Business Services"; and "Rental of Machinery Equipment, Personal Effects and Household Goods"), and the other knowledge-intensive services ("Activities Related to Human Health"). Second, the selection sought to include subsectors considered important for the economic development of the country, such as the tourism-related ones ("Restaurants and Hotels", "Transport", "Post and Telecommunications", "Electricity, Gas, Steam and Hot Water" and "Water Collection, Purification and Distribution").

There are two waves of Services Innovation Surveys (SIS) available in Uruguay at the moment: 2004–2006 and 2007–2009. The data is collected in parallel with the Economic Activity Survey (EAS) (same sample and statistical framework). All the firms with more than 49 workers are of mandatory inclusion. Units with 20 to 49 employees and with fewer than 19 workers are selected using simple random sampling within each economic sector at the ISIC 2-digit level up to 2005. Since then, random strata are defined for units with fewer than 50 workers within each economic sector at the ISIC 4-digit level. The number of firms included in the 2004–2006 and 2007–2009 samples is 900 and 1046, respectively.

Both surveys have been matched with the EAS. We matched both SIS with the 2004 and 2007 EAS because we needed information on capital (fixed assets) for the firm. In order to avoid endogeneity problems associated to the capital, we use this variable at the beginning of the period of the survey. All the other variables used in the empirical exercise come from the SIS.

The final number of included firms in the empirical exercises is 1868; 885from the first survey, and 983 from the second one. When using the capital per worker variable the sample is reduced to 1093, 776 for the 2004–2007survey, and 317 firms for the last survey available.[1,2]

In order to compare results with the manufacturing sector, we replicate the exercise using two waves of Manufacturing firms Innovation Surveys (MIS) (2004-2006 and 2007-2009) and the annual Economic Activity Surveys (EAS) for the period 2004–2007. The final number of included firms is 1733; 818 for 2004-2006 survey, and 915 for the last one. When using capital per employee the number of firms reduces to 1,213, 757 for the survey 2004–2006, and 456 for the last survey.[3]

Because of the salient heterogeneity that exists in the service sector, we investigate how the results differ by subsamples of firms in the Knowledge Intensive Business Services (KIBS), and traditional sectors.[4] We also study how the results differ for small firms (less than 50 employees). We do

[1]Firms with missing information were also excluded, also were excluded the percentile 1 and 99 of productivity and the percentile 99 of innovation expenditure per employee.
[2]The matching with the EAS was not without loss. The 2004–2006 SIS was performed with the same sampling frame of the EAS 2005. This implied that a significant number of firms that were surveyed in the 2004–2006 SIS, did not participate in the 2004 EAS. A similar problem arises when matching the 2007–2009 SIS (which is a subsample of the 2009 EAS) and the 2007 EAS. Both facts explain the loss of observations when matching the surveys.
[3]Same treatment as the SIS was performed with the MIS. Firms with missing information, and the percentile 1 and 99 of productivity and the percentile 99 of innovation expenditure per employee were excluded. Matching problems between EAS and MIS, as consequence of different sampling frame, explain the loss of observations.
[4]KIBS are defined using ISIC 3.1 codes: 72, 73 and 74 (Except 7492, 7493 y 7499).

the same for the manufacturing sector, studying the heterogeneity between high tech, low tech and small firms in the manufacturing sector.[5]

Table 2 to 4 show descriptive statistic for the services and manufacturing sector. As table 2 shows manufacturing firms are more innovative than services firms. In fact, while 40 percent of the services sector firms innovate, in the manufacturing sector this figure is higher, 43 percent.

The biggest heterogeneity between manufacturing and services in terms of innovation comes from technical innovation (defined as process or product innovation). 38 percent of the firms in the manufacturing sector report to do technical innovation, while 31 percent in the services sector. Meanwhile, the difference in the non-technical innovation propensity favors services (24 percent vs. 20 percent in manufacturing).

One interesting fact is that 37 percent (35 percent) of the firms in the service (manufacturing) sector that do any type of innovation, do both technical and non-technical innovation. Figure 1 shows the share of firms that report to do technical (vertical axis) and non-technical (horizontal axis) innovation. There is a clear positive correlation among the innovations.

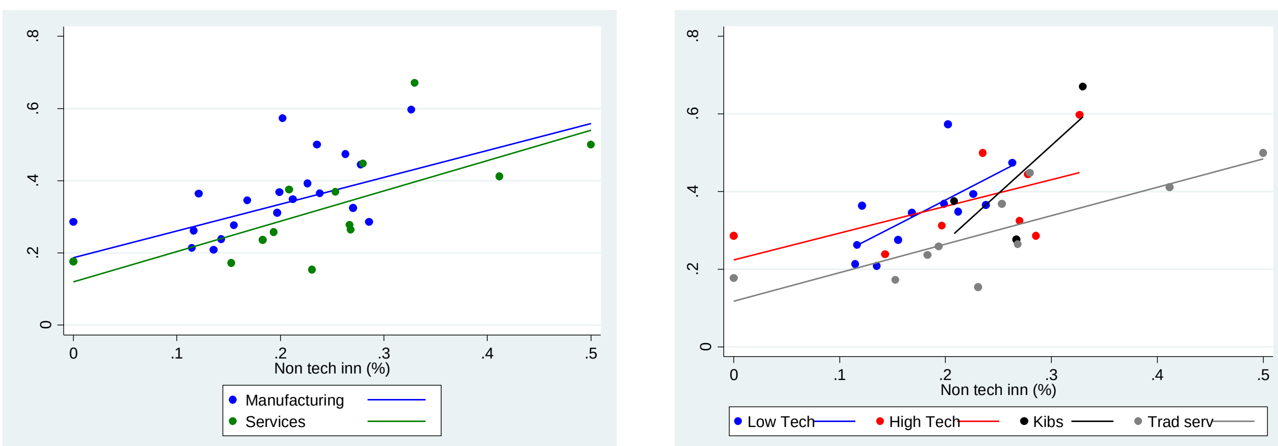
[5]High tech firms in the manufacturing sector are defined using the ISIC 3.1 codes: 24, 29, 30, 31, 32, 33, 34 y 35 (except 351).

Table 2. Innovation Behavior of Firms *(share of firms)*

		Technological Innovation					Non-Technological Innovation				
	N	Product	Process	Tech Innovation (1)	In-house Tech-Innov (2)	New to Market (3)	Organization	Marketing	Non-Tech Innovation (4)	Any Innovation (5)	Tech and Non-Tech Innovation (6)
All Service Industry	**1,868**	**0.183**	**0.242**	**0.307**	**0.008**	**0.127**	**0.203**	**0.094**	**0.244**	**0.398**	**0.152**
KIBS	628	0.221	0.252	0.338	0.014	0.159	0.250	0.086	0.274	0.436	0.175
Traditional	1,240	0.163	0.237	0.291	0.005	0.111	0.179	0.098	0.228	0.379	0.140
Small	1,133	0.144	0.186	0.238	0.006	0.109	0.142	0.071	0.176	0.314	0.100
National	1,675	0.170	0.240	0.299	0.009	0.119	0.187	0.085	0.223	0.379	0.142
Foreign	193	0.290	0.259	0.378	0.000	0.202	0.337	0.176	0.425	0.565	0.238
All Manuf. Industry	1,727	**0.234**	**0.325**	**0.380**	**0.010**	**0.153**	**0.166**	**0.085**	**0.204**	**0.430**	**0.153**
Low Tech	1,328	0.204	0.304	0.351	0.008	0.136	0.150	0.070	0.183	0.398	0.136
High Tech	399	0.333	0.393	0.476	0.020	0.211	0.218	0.133	0.273	0.536	0.213
Small	1,037	0.159	0.220	0.263	0.014	0.103	0.103	0.047	0.134	0.303	0.095
National	1,529	0.221	0.302	0.356	0.010	0.147	0.154	0.076	0.193	0.405	0.144
Foreign	198	0.333	0.505	0.561	0.010	0.202	0.258	0.152	0.288	0.621	0.227

(1) Product or process innovation, (2) Firms declare doing Internal R & D and tech inn,(3) New to Market product innovation, (4) Organization or marketing innovation,
(5) Technological or non-technological innovation, (6) Technological and non-technological innovation

Figure 1. Technical and Non-technical Innovation *(share of firms, at ISIC 2-digit level)*



Note: Share of firms that report to do technical (product or process) and non-technical (organizational or marketing) innovation.

High tech firms inside the manufacturing sector, and KIBS in the service sector tend to innovate more than the rest. In fact, KIBS show similar innovation behavior as the average of the manufacturing sector. Small and national firms have lower innovation propensity than the average. Table 3 shows that innovation expenditure as percentage of turnover is bigger in the service sector. 11 percent (12 percent) of this expenditure is invested on R&D in the service (manufacturing) sector, while 27 percent (47 percent) for the acquisition of machinery. The expenditure on innovation and on R&D is very similar when KIBS and high-tech firms are compared. 11 percent of the firms in the service sector performed R&D, while 16 percent did in the manufacturing sector. 31 percent of the high-tech firms and 17 percent of the KIBS performed R&D. Finally, for both, services and manufacturing, 11 percent of the turnover is due to new product innovation.

Table 3. Inputs and Outputs from Innovation

	Inputs						Outputs	
	Expenditure on innovation (1)	R&D (2)	Machinery Acquisition (3)	Other Innovation activities (4)	Firms that performed R&D	Firms that performed R&D on a continuous basis	Turnover from product innovations (5)	Turnover from new to market product innovations
All Service Industry	**1.71**	**11.24**	**27.03**	**61.74**	**10.65**	**13.97**	**11.35**	**4.27**
KIBS	1.90	17.94	10.47	71.60	16.56	20.06	13.85	6.41
Traditional	1.61	7.35	36.63	56.02	7.66	10.89	10.09	3.19
Small	1.64	11.31	22.17	66.53	7.24	8.74	9.32	3.15
National	1.72	11.91	28.68	59.41	10.21	13.07	10.62	4.02
Foreign	1.67	7.31	17.35	75.35	14.51	21.76	17.72	6.39
All Manuf. Industry	**1.90**	**12.01**	**47.04**	**40.95**	**15.98**	**33.82**	**11.25**	**4.26**
Low Tech	1.90	8.57	53.20	38.23	11.60	30.05	9.98	3.70
High Tech	1.91	20.61	31.64	47.75	30.58	46.37	15.47	6.11
Small	1.44	13.53	42.65	43.82	9.55	19.09	7.86	2.77
National	1.92	12.26	48.44	39.30	14.72	31.26	10.49	4.01
Foreign	1.77	10.81	40.24	48.95	25.76	53.54	17.09	6.17

(1) Total expenditures on innovation (as a % of total turnover), (2) Expenditure on R&D (internal) as a % of total expenditure on innovation
(3) Expenditure on machinery acquisition as a % of total expenditure on innovation, (4) Expenditure on the rest of innovation activities as a % of total expenditure on innovation, (5) Share of product innovation in turnover

Table 4 show statistics for policy related variables. From this table some important heterogeneities between services and manufacturing stand out. In the first place, manufacturing firms tend to export more than service sector firms for all sub-groups. While the cooperation with clients and providers, and in R&D seems to be similar between the two sectors, cooperation with universities is more important in the manufacturing than in the service sector. The share of firms that receive financial public support is higher in the manufacturing than in the services sector, especially for high tech firms. The patent behavior clearly differs between the two sectors. Firms in the manufacturing sector show higher propensity to apply for patents than services firms.

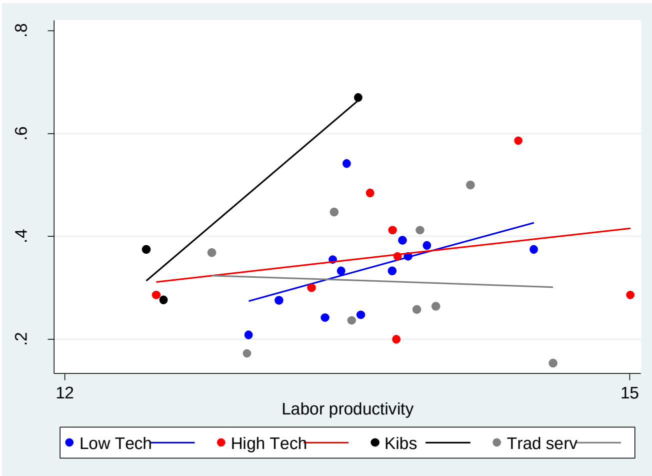
Table 4. Policy Related Variables

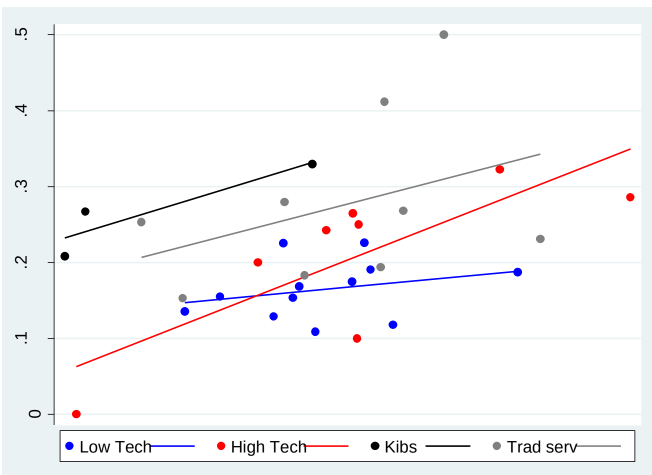
	International markets (1)	Co-operated with clients, providers (2)	Co-operated in R&D (3)	Co-operated with Universities or Gov. (4)	Public Support (5)	Applied for patents (6)
All Service Industry	**0.067**	**0.912**	**0.136**	**0.031**	**0.021**	**0.013**
KIBS	0.080	0.933	0.167	0.043	0.019	0.014
Traditional	0.060	0.902	0.120	0.025	0.023	0.012
Small	0.071	0.914	0.100	0.023	0.016	0.008
National	0.050	0.905	0.116	0.019	0.024	0.011
Foreign	0.168	0.868	0.160	0.094	0.009	0.019
All Manuf. Industry	**0.175**	**0.929**	**0.136**	**0.067**	**0.042**	**0.023**
Low Tech	0.181	0.931	0.103	0.050	0.037	0.018
High Tech	0.153	0.922	0.246	0.120	0.058	0.038
Small	0.090	0.930	0.073	0.037	0.023	0.014
National	0.138	0.932	0.122	0.051	0.043	0.020
Foreign	0.461	0.909	0.242	0.187	0.035	0.045

(1) Share of firms that export, (2) Share of firms that co-operated with clients or providers (3) Share of firms that co-operated in R&D on innovation activities, (4) Share of firms that co-operated with Universities/Higher education or government research institutes, (5) Share of firms that received public financial support for innovation
(6) Share of firms that applied for one or more patents

Appendix A presents tables 2 to 4 by services subsector (at ISIC two digit level). Finally, in Figure 2 we show the correlation of the technological and non-technological propensity to innovate and productivity (at ISIC 2 digit level) for KIBS, traditional services, and low and high tech manufacturing. For all subsectors (with the exception of traditional services) tech and non-tech innovations are positively correlated with productivity. In the traditional services technological innovation is negatively correlated with the level of productivity, but as we will see later on, at firm level and after controlling for other determinants, productivity will be positively associated to technological innovation in this subsector as well.

Figure 2. Technical and Non-technical Innovation and Productivity *(at ISIC 2 digit level)*





Note: Vertical axis: share of firms in the subsector that report technical (product or process) or non-technical (organizational or marketing) innovation.

4. Empirical Strategy

Among the first approaches to analyze the impact of innovation on productivity, is the work of Griliches (1979), which established a method for modeling such link that has been incorporated in most of the latter studies. Innovation is modeled through a "knowledge production function" that accounts for the fact that production of knowledge is a result of past and current investment in knowledge, as well as other exogenous factors. On the other hand, the effects on productivity are modeled through an output production function that is an expression of the amount of output accomplished by using a certain amount of inputs, one of them being knowledge.

With that in mind, the model by Crépon, Duguet and Mairesse (1998)—CDM model—offers a method to empirically estimate the innovation-productivity link, by combining the conceptual considerations provided by Griliches with a recursive model. The CDM model comprises the entire process that starts at the firm's decision to undertake R&D activities or more broadly innovation activities –innovation input- to the impact that innovation activities have on innovation and finally to the resulting effects of innovations -innovation output- on firm's performance. In this sense, the model incorporates the study of the three following links: the main factors that influence the process of innovation; the relation between innovation activities and innovation output; and the link relating innovation output to productivity.

The CDM model allows the correction of some of the biases that generally affect the measurement and study of innovation, in particular, the selection bias. The problem is that we only observe expenditure in innovation activities for those firms that declare to invest in innovation activities. We know, at least since Heckman (1979), that this can generate sample selection bias in our estimated parameters of interest if we do not take into account the decision or selection equation. It is important to note that the elimination of this bias becomes even more important when applying the model to the service sector, for services are characterized for the informal and ad-hoc nature of their innovation activities.

The CDM model also addresses the issue of simultaneity between innovation activities, innovation output and productivity by stating a model divided in three stages –innovation input, innovation output and productivity- and making the results of each one of the stages an endogenous variable to the following one. Thus, innovation expenditure is an endogenous variable to the innovation equations, and innovation is an endogenous variable to the productivity equation. The resulting model consists of a system of four non-linear equations in which simultaneity is dealt with by using a multiple-stage estimation procedure.

This paper follows the version of the CDM model proposed by Crespi and Zuñiga (2010). However, we will introduce a minor change in the estimation strategy of the innovation output equation, distinguishing between technological innovations (product and process) and non-technological ones (organizational and marketing innovations), and estimating them simultaneously using a bivariate probit. In addition, in some of the equations some additional variables will be included.

Crespi and Zúñiga (2010) provide a version of the CDM model adapted to Latin America's manufacturing sector specificities. Firstly, the study considers patent statistics as a less relevant variable when describing innovation, given that firms' innovations rarely occur at a frontier level. Therefore, patents are substituted by using qualitative information on innovation provided by innovation surveys. Also, the model uses a broader concept of innovation investment when measuring such variable. In that regard, while the traditional CDM model only accounts for R&D investments, the model for Latin America measures R&D expenditures as well as other types of investment that can potentially lead to the generation of innovation output such as investment in design, installation of machinery, industrial engineering, embodied and disembodied technology, marketing, and training ("innovation expenditure").

4.1 Innovation Activities Equations

The innovation activities equations for this model are meant to explain the behavior of firms in two complementary ways. The first one is represented by the first equation and accounts for the determinants of the decision to engage in innovation activities. The vector of explanatory variables is composed by the firm's number of employees (firm size), a dummy indicating if the firms is an exporter, a dummy indicating if more than 10 percent of the capital of the firm is foreign owned, a dummy indicating if the firm applied for patent protection, dummy variables indicating if the firm received public financial support for innovation activities, if the firm cooperated with other firms to carry out R&D activities, if the firm considers market, scientific or public sources of information important for the innovation activities and finally if the firm perceives that there are meso-economic (for example at the sectoral level) credit restrictions. Industry dummies are also included in regressions.

The justification for the inclusion of size at this stage is that if fixed costs of innovation exist (e.g., the cost of installing R&D labs), larger firms can better diffuse these costs and therefore are more likely to invest in innovation activities. Here, the dependent variable is defined as an indicator of the firms "willingness" to carry out innovation activities: if the innovation expenditure is positive, then innovation activities will take place. Thus, the *innovation decision* equation could be expressed as follows:

$$(1) ID_i = 1 \text{ if } w_i\alpha + \varepsilon_i > c$$

$$ID_i = 0 \text{ if } w_i\alpha + \varepsilon_i \leq \text{c}$$

Where ID_i is the innovation decision binary variable which is 1 for firms who decide to innovate and 0 for firms who do not, w is the vector of explanatory variables that determine the decision, α is the vector of parameters, ε is the error term, and *c* is the threshold level that determines whether the firms decides to invest in innovation or not.

The second component is derived from a second equation that accounts for the magnitude or intensity of innovation activities carried out by firms. In this regard, the variable considered is the actual innovation expenditure per employee. As for the explanatory variables we make the assumption that the variables that affect the process of decision making regarding the engaging to a certain innovation activity can potentially determine also the magnitude of that activity, but because we are using innovation expenditure per employee, the variable size (number of employees), are not included in the second equation (this exclusion will also allow the identification of the first equation without resting only on the function form of the model). Implicitly, since our dependent variable is innovation expenditure per employee, we are assuming that innovation expenditure is strictly proportional to size (the number of employees).

Accordingly, the equation for *innovation effort (or expenditure)* would be:

$$(2) \quad IE_{\mathrm{i}} = z_i\beta + e_i \text{ if } ID_i = 1$$

$$IE_{\mathrm{i}} = 0 \qquad \text{if } ID_i = 0$$

Where IE is the magnitude of innovation effort (the log innovation expenditure per employee in our case), z is the vector of explanatory variables for investment in innovation activities, β is the vector of parameters and *e* is the disturbance.

For the second variable (innovation effort) to be observable the first one (innovation decision) has to surpass the stated threshold. Otherwise, no research would occur and there would be no magnitude or intensity to measure. A Heckman model will be estimated in this first stage.

4.2 Innovation Equation

As stated before, the CDM model offers a different equation for innovation, also referred to as knowledge production function. In fact, we will have two different equations, one for technological innovations and one for non-technological innovations. Here, the “technological innovation” (product or process innovation) and the “non-technological innovation” (organizational or marketing innovation) are the dependent (dummy) variables that are used as a proxy for innovation output.

In this sense, the innovation output is explained by the magnitude of the innovation activity –that is endogenous to the model and comes from the second innovation activities equation- and by a set of exogenous variables: the same included in the first stage with the exception of the variables public financial support (and credit and human capital restrictions in some of the regressions). This implies the assumption that public financial support (and credit and human capital restrictions in some regressions) does not affect innovation output directly, but only indirectly through the level of innovation activities (proxied by the log innovation expenditure per employee). The *innovation output* equations or *knowledge production functions* are:

$$(3)\begin{pmatrix} TI_i \\ NTI_i \end{pmatrix} = \widehat{IE}_{\mathrm{i}}\gamma + \mathrm{x_i}\delta + \mathrm{u_i}$$

Where TI is a dummy indicating technological innovation outputs (product or process innovation) and NTI is a dummy for non-technological innovation outputs (organizational or marketing innovation), IE is the endogenous explanatory variable that results from equation (2) (we will use its predicted value $\widehat{IE}_{\mathrm{i}}$ in these equations),γ is a diagonal matrix of parameters and δ is block diagonal matrix of parameters, *x* is a block diagonal matrix of determinants of innovation production, and *u* is the error vector.

We will estimate a bivariate probit model at this stage, instead of a linear model, as equation (3) may suggest estimating. We are assuming then that the errors of both equations follow a bivariate normal distribution; allowing for correlation between them.

4.3 Productivity Equation

For the productivity equation, CDM takes a Cobb-Douglas production function with physical capital, employment, and innovation outputs (or alternatively, innovation expenditure).

For this equation, log transformations are used, resulting in:

$$(4) y_i = c + \pi_1 k_i + \pi_2 l_i + \pi_3 \widehat{TI_\iota} + \pi_4 \widehat{NTI_\iota} + v_i$$

Where y_i is the log of output per worker (sales per worker in our estimations) –labor productivity-, c is a constant,$k_i$is the log of physical capital per worker,$l_i$is the number of workers (our variable size), $\widehat{TI_\iota}$ and $\widehat{NTI_\iota}$ are the predicted innovation outputs that results from equation (3), $\pi_1$toπ_4 are parameters and v_i is a disturbance term. In addition we will include in this equation industry dummies. In some of the regressions a proxy for human capital per employee (h_i) will also be added to the model:

$$(4') y_i = c + \pi_1 k_i + \pi_2 l_i + \pi_3 \widehat{TI_\iota} + \pi_4 \widehat{NTI_\iota} + +\pi_5 h_i + v_i$$

Alternatively to (4), we will also be estimating the following equation:

$$(4'') \; y_i = c + \pi_1 k_i + \pi_2 l_i + \pi_6 \widehat{IE_\iota} + \xi_i$$

Where π_5 and π_6 are parameters, and ξ is the error term.

5. Results

The findings from estimating the version of the CDM model presented in section4 for services and manufacturing firms with data from Uruguay are presented and analyzed in this section.

5.1 Innovation Activities Equations

Table 5 presents the findings from the first stage of the CDM model. The selection equation for engaging in innovation activities is shown in the left panel. The dependent variable is a dummy indicating whether a firm invests in innovation inputs or not. The right panel of the table shows the results of estimating an investment intensity equation, conditional on the decision to innovate. The dependent variable is the innovation expenditure per employee. We estimate this stage by standard Heckman procedures.

This stage shows that the determinants for performing innovation are very similar in the manufacturing and services sector. The use of measures of formal protection (patents applied for) and receiving public funding are positively related to firm's decision to invest in innovation activities. Larger exposure to international competition, as measured by the export orientation of the firm, is associated with higher probability of investing in innovation only for services firms. Cooperation in R&D and market sources of information are associated with higher probability of investing in innovation activities. Scientific sources of information seem to have negative or no effect. Being foreign owned has no significant impact. Finally, larger firm size is associated with the increased probability of investing in innovation inputs. Once controlled for this effect, it is assumed that the investment expenditure is linear in size. Note that the dependent variable is expenditure per employee of the firm (number of employees is our proxy for size).

The importance of determinants of the decision of how much to invest in innovation activities differs across sectors. The exposure to international markets has no effect on the level of investment in innovation for both sectors. The reverse is true for the foreign owned status and patent protection; both have a positive effect in the service sector. Instead, public financial support seems to affect positively the size of the investment only in the manufacturing sector. Cooperation in R&D continues to be important for both sectors in terms of the level of the investment. Public sources of information have a positive effect only in the case of services. Scientific sources and market sources of information have no effect on the level of investment.

Table 5. Innovation Expenditure Equation

Variable	Services	Manuf	Services	Manuf
Dep var	Probability of investing in innovation IE>0		Log (Innovation expenditure)=Log IE	
Exporter	0.375***	0.0709	0.518	0.159
	(0.0861)	(0.0642)	(0.323)	(0.106)
Foreign owned	0.141	0.0922	0.570**	0.0297
	(0.126)	(0.131)	(0.224)	(0.139)
Patent protection	1.491***	1.884***	0.503**	-0.383
	(0.329)	(0.525)	(0.245)	(0.349)
Public support	1.984***	2.182***	0.994	0.649***
	(0.413)	(0.506)	(0.660)	(0.247)
Cooperation in R&D	1.282***	1.525***	1.001***	0.525***
	(0.175)	(0.207)	(0.337)	(0.165)
Market information	0.520***	0.377***	0.367	0.291
sources (Info1)	(0.0944)	(0.108)	(0.299)	(0.203)
Scientific sources	-0.140	-0.259***	0.0410	-0.0193
(Info2)	(0.121)	(0.0980)	(0.173)	(0.207)
Public sources	0.00993	0.118	0.356***	0.0846
(info3)	(0.0902)	(0.105)	(0.0650)	(0.112)
Size	0.248***	0.372***		
	(0.0216)	(0.0247)		
Constant	-1.789***	-2.109***	-0.0637	2.219***
	(0.0626)	(0.129)	(0.565)	(0.336)
Industry dummies	yes	yes	yes	yes
Number of obs.	1,868	1,727	1,868	1,727
Log likelihood			1,433	-2273
Dependence (ρ)			0.578**	-0.0822
			(0.227)	(0.112)

*** p<0.01, ** p<0.05, * p<0.1. Errors clustered at 2 digit industry level.

5.2 Knowledge Production Function

Table 6 outlines the results of the estimation of the knowledge production function, with dummy variables for technical (product or process) and non-technical (organizational and marketing) innovation used as dependent variables. We estimate these equations with a bivariate probit regression, controlling for the correlation between the variables in the error term. The coefficients in the table show marginal effects of explanatory variables, estimated at the sample means.

The results, as expected, indicate that innovation output is determined significantly and positively by investments in innovation inputs, both in service and manufacturing sector. The predicted values for innovation investments are obtained from the previous stage of the CDM model—the innovation expenditure equation (stage 1 above).

We find that in the case of technical innovation, the effects of innovation expenditure are larger than those for non-technical innovation. It has been argued in the literature that product innovations are more linked to the technology used and could be more likely to result from formal and internalized R&D activities (Musolesi and Huiban, 2010). This could be explaining the higher correlation of innovation expenditures with technological innovation in our results.

Results also show that the effects of innovation expenditure are stronger in the service sector. It has been noted in the literature that in services it is more difficult to make the appropriate amount of innovation investment due to less information for predicting financial returns, which can cause both under- and over-investment in innovation (Voss and Zomerdijk, 2007). This may affect the observed link between innovation input and output, and could be explaining our results.

Additionally, we find that size is a very important determinant of the probability of undertaken technological and non-technological innovation in both sectors. This is an expected result; large firms have the advantage of spreading fixed costs (e.g., R&D labs' costs) over greater output, they have economies of scope, and they can better appropriate external knowledge spillovers (Cohen and Levinthal, 1989; Crespi and Zuñiga, 2010).

Table 6. Knowledge Production Function

	Services	Manufacturing	Services	Manufacturing
Variable\Dep var	**Technological innovation**		**Non technological innovation**	
Exporter	-0.363	-0.253**	0.111	-0.236***
	(0.230)	(0.0989)	(0.0928)	(0.0822)
Foreign owned	-0.878***	-0.116	0.105	-0.0591
	(0.216)	(0.131)	(0.113)	(0.117)
Patent protection	0.517**	2.060***	0.413	1.001***
	(0.215)	(0.327)	(0.400)	(0.155)
Cooperation in R&D	-0.142	0.183	0.368**	0.165
	(0.302)	(0.230)	(0.182)	(0.161)
Market information	0.00295	-0.261*	0.508***	0.0413
sources (Info1)	(0.101)	(0.152)	(0.105)	(0.150)
Scientific sources	-0.194**	-0.235**	-0.0397	-0.0579
(Info2)	(0.0890)	(0.113)	(0.0675)	(0.0616)
Public sources	-0.456***	0.0214	-0.114	0.244**
(info3)	(0.163)	(0.0948)	(0.122)	(0.122)
Size	0.196***	0.346***	0.227***	0.309***
	(0.0260)	(0.0318)	(0.0194)	(0.0300)
Log IE_p	1.387***	2.332***	0.399**	0.649***
	(0.293)	(0.333)	(0.197)	(0.240)
Constant	-1.682***	-7.578***	-2.391***	-3.898***
	(0.145)	(0.753)	(0.0566)	(0.569)
Industry dummies	yes	yes	yes	yes
Number of obs.	1,868	1,727	1,868	1,727
Log likelihood			-1809	-1587
Independece (rho)			0.563***	0.533***
			(0.0310)	(0.0399)

Note: Bootstrapped standard errors in parentheses (100 replications).
* Coefficient is statistically significant at the 10 percent level;
** at the 5 percent level; *** at the 1 percent level; no asterisk
means the coefficient is not different from zero with statistical significance.

Results with respect to other variables are less robust across innovation types and sectors, except perhaps with patents. Formal protection, as measured by (applications for) patents, has positive and significant effect on technological innovation, as expected. While this is true also in the manufacturing sector for non-technological innovation, in the service sector it has no significant effect. The effect of formal protection is stronger in the manufacturing sector than in the service sector. This is an expected result, service firms tend to rely less on patents and to generate innovations that are less patentable. Knowledge in services is less tangible and codified than in manufacturing (and this is especially true for non-technological knowledge) and these two attributes are important for patents. Therefore, patents are less relevant as intellectual property protection device and less relevant in the knowledge (innovation) production function in services, in particular for non-technological knowledge. For the same reasons, services make greater use of trademarks, brands, copyrights and other informal intellectual property right tools to protect their innovations (Blind et al., 2010).

With respect to the information sources for innovation, we find no robust evidence of a positive effect on innovation, above the positive effect that some of them have through the innovation expenditure. Moreover, some of them seem to have a negative impact. The only positive effect that we find comes from the information based on the market (clients, providers, etc.) in the case of the non-technological innovation services. This is consistent with the notion that services are closer (and interact more) with end-users than manufacturing, and that customers have an important role in defining service products (Barcet, 2010).

The other controls (i.e. being foreign owned, exporter and cooperate in R&D) have in general, and with only a few exceptions, no impact on the innovation output above that coming through the innovation expenditure. Being foreign owned has negative effect on technological innovation in the service sector; being an exporter have a negative effect in the case of manufacturing; and the cooperation in R&D has a positive effect only in the case of non-technological innovations in the service sector.

5.3 Productivity Equation

The final stage of the CDM model, which relates the labor productivity of firms to their innovation indicators, is shown in Table 6. The measure used for productivity is the log of sales per employee, the dependent variable. As a recursive model, this stage uses the predicted probability of performing technological innovation, non-technological innovation or both using the model estimated in the previous stage (columns 2 and 4). In column 1 and 3, we estimate the equation using the predicted innovation expenditure of stage 1. As shown in Table 6 innovation expenditure is significant and positively correlated with labor productivity, both in the manufacturing and service sector, and its impacts on productivity is similar for both sectors.

Results show that technological and non-technological innovations are significantly associated with higher firms' productivity in the service sector (column 2). Non-technological innovations have a bigger impact than technological innovations.

Table 7.Productivity Equation

	Services		Manufacturing	
Variable\Dep. Var.	log(sales/employee)			
Size	-0.0588***	-0.163***	0.188***	0.261***
	(0.0211)	(0.0336)	(0.0300)	(0.0432)
K/L	0.0695**	0.0724**	0.210***	0.208***
	(0.0297)	(0.0295)	(0.0514)	(0.0650)
Log IE_p	0.489***		0.471***	
	(0.0756)		(0.0965)	
I_Both_p		1.358***		-1.006***
		(0.297)		(0.290)
I_tech_p		1.177*		1.249***
		(0.669)		(0.299)
I_nontech_p		4.315***		-5.412***
		(0.889)		(1.292)
Constant	12.84***	12.95***	11.31***	12.51***
	(0.124)	(0.172)	(0.273)	(0.176)
Ind dumm	yes	yes	yes	yes
Observations	1,093	1,093	1,209	1,209
R-squared	0.385	0.379	0.300	0.311

Note: Bootstrapped standard errors in parentheses (100 replications).

* Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level;

*** at the 1 percent level; no asterisk means the coefficient is not significant.

Even though we know that non-technological innovations are more frequent in services than in manufacturing and that this could have implications in terms of the relative impact of technological vs. non-technological innovations on productivity, the evidence so far is scarce. Polder et al. (2010) using data for UK firms show that organization innovation is the only type of innovation that drivers productivity, measured as TFP, and that this effect is strong in the service sector. Masso and Vahter (2012) for Estonia find that non-technological innovation plays a positive role only in some specifications of the productivity equation, and that in general technological innovation seems to be more important.

In manufacturing, only technological innovations improve productivity. Non-technological innovations, alone or in combination with technological innovations, are associated with a reduction in productivity. In a similar regression, Crepi and Zuñiga (2010) find also a negative coefficient for the non-technological innovation variable for the Uruguayan manufacturing sector, but the coefficient is not statistically different from zero. Size is significant in all regression, and has positive sign for manufacturing and negative for services. Finally, capital per worker is significant and positive in both sectors, but probably due to differences in the production function (services are more labor intensive), the effect is stronger in the manufacturing sector.

6. Heterogeneity across Subsectors

In this section we explore the possible heterogeneity across subsectors. In Tables 8–10 the exercise of section 5 is replicated for different subsamples: KIBS versus traditional firms in services, low versus high tech firms in manufacturing, and small firms in each sector.

6.1 Innovation Activities Equations by Subsector

When subsectors are analyzed some heterogeneities but also some common factors are found. For the decision to innovate, to be an exporter is important for all service firms but not for the different manufacturing subsector. It seems to be important to have applied for patent protection for all types of firms (except small manufacturing), but especially so for KIBS and High-tech firms (bigger coefficient). Probably, because KIBS and High Tech firms are closer to the technological frontier, and because the knowledge that they generate can be codified more easily than in other subsectors (particularly in KIBS vis a vis other service subsectors) patent protection is more relevant for them.

Size, cooperation on R&D and market sources of information are relevant for the decision to invest in innovation activities for all types of firms. Size is more important for manufacturing subsectors than for services subsectors. Market sources of information are more important for the service subsectors. Market sources of information continue to be more important for services. Public sources of information are relevant only for small firms. Scientific sources of information affect in general negatively the decision to invest in innovation activities in all subsectors, except in the case of KIBS and small service firms, where no effect is found.

Table 8. Innovation Expenditure Equation by Subsectors

	KIBS	Traditional	Small	Hightech	Low Tech	Small
Variable\Dep. Var.	**Innovation expenditure dummy (Probability of investing in innovation IE>0)**					
Exporter	0.443***	0.326**	0.300***	0.179	0.0516	0.135
	(0.0257)	(0.134)	(0.108)	(0.112)	(0.0865)	(0.119)
Foreign owned	-0.0376	0.276**	0.305	-0.152	0.164	0.220
	(0.238)	(0.130)	(0.219)	(0.260)	(0.148)	(0.218)
Patent protection	7.098***	1.348***	0.883**	5.457***	1.747***	8.003
	(2.129)	(0.375)	(0.425)	(0.136)	(0.583)	(222,785)
Public support	7.699***	1.874***	2.060***	1.608**	6.061***	13.80
	(1.970)	(0.481)	(0.463)	(0.676)	(0.135)	(46,389)
Cooperation in R&D	1.341***	1.194***	1.759***	1.107***	2.080***	1.574***
	(0.408)	(0.216)	(0.325)	(0.175)	(0.371)	(0.325)
Market information	0.447**	0.557***	0.312***	0.368**	0.368***	0.236*
sources (Info1)	(0.205)	(0.0802)	(0.103)	(0.170)	(0.135)	(0.133)
Scientific sources	0.0919	-0.277**	-0.0476	-0.489***	-0.181*	-0.381***
(Info2)	(0.102)	(0.113)	(0.0730)	(0.156)	(0.105)	(0.120)
Public sources	-0.0122	0.0229	0.221*	0.0488	0.126	0.229**
(info3)	(0.0459)	(0.132)	(0.121)	(0.128)	(0.125)	(0.113)
Size	0.275***	0.255***	0.254***	0.444***	0.353***	0.443***
	(0.0218)	(0.0273)	(0.0697)	(0.0605)	(0.0225)	(0.0711)
Constant	-1.916***	-1.796***	-1.979***	-2.853***	-2.078***	-2.313***
	(0.0946)	(0.0766)	(0.215)	(0.371)	(0.149)	(0.309)
Variable\Dep. Var.	**Log (Innovation expenditure)=Log IE**					
Exporter	0.868	0.256	0.210	0.301	0.103	0.257
	(0.686)	(0.233)	(0.385)	(0.294)	(0.128)	(0.216)
Foreign owned	0.447	0.664***	0.629**	-0.0162	0.0708	0.273
	(0.514)	(0.229)	(0.306)	(0.132)	(0.199)	(0.351)
Patent protection	1.051***	0.274	0.0889	-0.0486	-0.571	0.523
	(0.0853)	(0.277)	(0.596)	(0.141)	(0.576)	(0.497)
Public support	1.234	0.834	0.743	0.441***	0.708**	1.070**
	(1.293)	(0.743)	(0.519)	(0.162)	(0.337)	(0.469)
Cooperation in R&D	1.269**	1.023**	0.792	0.599*	0.476**	1.079***
	(0.601)	(0.494)	(0.539)	(0.327)	(0.204)	(0.356)
Market information	0.781***	0.111	0.104	0.0287	0.432*	0.261
sources (Info1)	(0.129)	(0.406)	(0.546)	(0.265)	(0.256)	(0.301)
Scientific sources	0.424	-0.226	-0.115	0.162	-0.112	-0.206
(Info2)	(0.279)	(0.187)	(0.160)	(0.279)	(0.211)	(0.236)
Public sources	0.271***	0.431***	0.422	0.113*	0.0853	-0.0249
(info3)	(0.0863)	(0.0997)	(0.257)	(0.0636)	(0.154)	(0.233)
Constant	-1.269	0.511	1.161	2.341***	2.172***	1.651**
	(1.031)	(0.457)	(1.231)	(0.250)	(0.468)	(0.664)
Industry dummies	yes	yes	yes	yes	yes	yes
Number of obs.	628	1,240	1,133	399	1,328	1,037
Log likelihood	-865.9	-1558	-1215	-568.8	-1690	-1061
Independence (ρ)	1.025***	0.453**	0.111	-0.00438	-0.0933	0.242
	(0.340)	(0.189)	(0.398)	(0.192)	(0.140)	(0.206)

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

Public support is relevant for all type of firms except small manufacturing firms. The biggest impacts of this variable are found for KIBS and low-tech firms. The origin of firms' capital is not a relevant factor for the decision to invest in innovation activities, except in the case of traditional services (and only at 5 percent level of confidence).

It is interesting to note, that many factors that are relevant for the decision to invest, are not relevant for the amount invested in innovation activities by firms. In particular, the only two determinants that seem to be important across all manufacturing subsectors are cooperation in R&D and public support. In addition public sources of information are relevant for high-tech firms at 10 percent level of confidence, and market sources of information have a positive impact in low-tech firms (again at 10 percent confidence).

For KIBS patent protection, cooperation in R&D, and market and public sources of information are the variables that affect significantly (and positively) the level of innovation expenditure. Cooperation in R&D, public sources of information and to be foreign owned are the relevant variables for traditional services. The only significant variable for the small service firms is foreign owned.

The only variable that consistently appears significantly across all services and manufacturing subsectors regressions (except small services) is cooperation in R&D. This seems to be one of key variables to determine the level of innovation expenditures across subsectors.

6.2 Knowledge Production Function by Subsectors

When it comes to innovation output, size seems to matter for all types of innovation (tech and non-tech innovation) and subsectors. The amount invested in innovation activities is an important determinant of the innovation output. It seems to be more important for technological than for non-technological innovation. The coefficient of the innovation expenditure variable is not statistically different from zero for non-technological innovation in traditional and small services and high-tech manufacturing. Non-technological innovation probably requires innovation activities that are less dependent on the amount invested by the firm, since they are obtained in a less formalized process (e.g., learning from the contact with clients, etc.).

Patent tends to have, in general, a positive impact across types of innovation and subsectors (the coefficient is positive and significant in 7 out 12 regressions), but again it seems to be more important for the production of technological innovations. The variable is not significant in the case of innovations produced in small manufacturing firms and KIBS and in the case of non-tech innovations in small service firms.

The sources of information variables appear with negative signs in many of the regressions. Market information is relevant for innovation in almost all subsectors (in addition to its impact through innovation expenditure), but the sign of the impact is negative for some subsectors. In particular it has a negative (and significant) effect in the case of low-tech manufacturing firms, for tech innovations in KIBS and for non-tech innovations in small manufacturing firms. Again, the impact of scientific sources tends to have negative or no impact on innovation, the only positive and significant impact is found for non-tech innovation in small service firms. Public sources of information have negative or no impact for services and positive or no impact for manufacturing.

Table 6. Knowledge Production Function by Subsector

Variable	KIBS	Traditional	Small	KIBS	Traditional	Small	High Tehc	Low Tech	Small	High Tehc	Low Tech	Small
Dep var	Technological inn			Non technological inn			Technological inn			Non technological inn		
Exporter	-0.345	-0.139	0.00257	-0.141	0.195**	0.00536	-0.632***	-0.162	-0.300	-0.742**	-0.0971	-0.560***
	(0.318)	(0.251)	(0.182)	(0.237)	(0.0963)	(0.137)	(0.232)	(0.136)	(0.204)	(0.309)	(0.0731)	(0.132)
Foreign owned	-0.527	-1.236***	-0.935**	0.0652	0.0905	-0.0558	-0.356**	-0.0632	-0.595***	-0.111	-0.0654	-0.226
	(0.382)	(0.344)	(0.376)	(0.0662)	(0.183)	(0.356)	(0.169)	(0.140)	(0.181)	(0.251)	(0.135)	(0.252)
Patent protection	0.123	1.030***	0.804*	-0.506	0.916**	0.349	1.662***	2.374***	0.450	0.961***	0.986***	0.435
	(0.282)	(0.320)	(0.422)	(0.432)	(0.367)	(0.406)	(0.112)	(0.436)	(0.417)	(0.111)	(0.218)	(0.278)
Cooperation in R&D	0.0572	-0.469	0.0410	0.114	0.363*	0.552	-0.162	0.215	-0.518	-0.507	0.410**	-0.775**
	(0.0422)	(0.630)	(0.335)	(0.442)	(0.220)	(0.485)	(0.429)	(0.270)	(0.572)	(0.597)	(0.172)	(0.326)
Market information	-0.287***	0.435***	0.359***	0.263	0.594***	0.252	0.0346	-0.462**	-0.0948	0.830***	-0.183*	-0.329*
sources (Info1)	(0.0101)	(0.0797)	(0.0799)	(0.443)	(0.115)	(0.179)	(0.204)	(0.206)	(0.185)	(0.170)	(0.104)	(0.186)
Scientific sources	-0.386*	0.0712	0.0560	-0.176***	-0.0309	0.218**	-0.927***	0.0211	-0.0190	-0.523**	0.0833	0.104
(Info2)	(0.218)	(0.153)	(0.0799)	(0.0162)	(0.0505)	(0.0919)	(0.186)	(0.120)	(0.186)	(0.247)	(0.0573)	(0.168)
Public sources	-0.155**	-0.741**	-0.434*	-0.195	-0.0650	-0.210	-0.166	0.0255	0.367***	0.172	0.254*	0.462**
(info3)	(0.0733)	(0.295)	(0.251)	(0.129)	(0.155)	(0.251)	(0.244)	(0.105)	(0.101)	(0.256)	(0.149)	(0.209)
Size	0.145***	0.225***	0.215**	0.215***	0.240***	0.247***	0.365***	0.340***	0.392***	0.360***	0.288***	0.331***
	(0.00309)	(0.0158)	(0.0850)	(0.0236)	(0.0281)	(0.0675)	(0.112)	(0.0306)	(0.0897)	(0.0720)	(0.0329)	(0.0673)
Log IE_p	0.888***	1.907***	1.548***	0.587*	0.366	0.777	2.993***	2.273***	1.684***	1.367	0.534**	1.220***
	(0.259)	(0.576)	(0.487)	(0.337)	(0.240)	(0.544)	(0.928)	(0.392)	(0.366)	(0.840)	(0.262)	(0.249)
Constant	-0.549***	-2.941***	-3.898***	-1.511***	-2.650***	-3.307***	-9.360***	-7.399***	-5.242***	-6.481***	-3.461***	-4.586***
	(0.209)	(0.359)	(0.462)	(0.445)	(0.120)	(0.734)	(2.427)	(0.871)	(0.693)	(2.249)	(0.635)	(0.434)
Industry dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Number of obs.	628	1,240	1,133				399	1,328	1,037			
Log likelihood	-637.5	-1165	-974.8				-394.2	-1179	-790.2			
Independece (rho)	0.618***	0.533***	0.574***				0.543***	0.548***	0.630***			
	(0.0304)	(0.0344)	(0.0280)				(0.0602)	(0.0492)	(0.0669)			

Note: Bootstrapped standard errors in parentheses (100 replications).
* Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level; no asterisk means the coefficient is not different from zero with statistical significance.

Cooperation in R&D tends to be not relevant for innovation (in addition to its impact through innovation expenditure). It has a significant effect only in 3 out of 12 regressions and only at 5 percent or 10 percent level of confidence and, in 2 cases with negative sign.

To perform export activities tend to have in general negative or no effect on innovation, with the exception for non-tech innovation in traditional firms where the impact is positive. Foreign owned has in general no impact on innovation, but in 4 of the regressions it has a negative and significant impact. What seems to be happening is that many of the variables included in the innovation output equation are not having additional effects on innovation other than that that comes from their effects on investment expenditure. In the case where such additional effect exists, it tends to be negative.

6.3 Productivity Equation by Subsectors

For service firms, size is a variable that affects negatively (although not significantly in a couple of cases) the productivity, except in the case of small firms when innovation expenditure is used as a proxy for innovation and at 10 percent level of confidence. The capital intensity impacts positively the productivity, except for KIBS where it has no effect. Non-tech innovation has a bigger impact on productivity than non-tech innovation (columns 2, 4 and 6). Tech innovation is more important for productivity in small and traditional service firms than for KIBS. The reverse happens in the case of non-tech innovations; in particular tech innovation is not significantly different from zero for KIBS. When innovation expenditure is used as a proxy for innovation (columns 1, 3 and 5) again a positive impact on productivity is found, but it seems to have a more important role in the case of small and traditional services.

For manufacturing firms, size is a variable that affects positively the productivity, except in the case of small firms where it has no effect when the innovation probabilities are used as a proxy for innovation. The capital intensity has a positive effect on productivity across subsectors. Technological innovation is what matters for productivity in manufacturing, except perhaps for high-tech firms where the coefficient is not significantly different from zero. Technological innovation seems more important for small and low tech manufacturing, and in this order. Non-tech innovation tends to have negative or no effect on productivity. The negative effect is bigger in the case of high-tech firms. When (the predicted value of) innovation expenditure is used as proxy for innovation, we found that innovation is important for productivity for all types of manufacturing firms, but again it is more important for small and low-tech manufacturing.

Table 10. Productivity Equation by Subsector

	KIBS		Traditional		Small	
Variable\Dep. Var.	**log(sales/employee)**					
Size	-0.192***	-0.393***	-0.0141	-0.151***	0.130*	-0.0598
	(0.0429)	(0.0658)	(0.0249)	(0.0441)	(0.0670)	(0.0870)
K/L	0.630	0.678**	0.0642**	0.0663**	0.0910***	0.0962***
	(0.385)	(0.344)	(0.0284)	(0.0314)	(0.0263)	(0.0287)
Log IE_p	0.237***		0.526***		0.756***	
	(0.0492)		(0.0870)		(0.139)	
I_Both_p		1.427***		1.184***		1.280**
		(0.485)		(0.382)		(0.532)
I_tech_p		0.508		1.880***		2.080*
		(0.667)		(0.677)		(1.114)
I_nontech_p		6.273***		3.605***		4.984***
		(1.344)		(1.162)		(1.641)
Constant	13.89***	14.03***	12.53***	12.75***	10.97***	12.04***
	(0.198)	(0.335)	(0.134)	(0.177)	(0.259)	(0.230)
Ind dumm	yes	yes	yes	yes	yes	yes
Observations	343	343	750	750	562	562
R-squared	0.301	0.333	0.342	0.340	0.409	0.402
	High Tech		**Low Tech**		**Small**	
Size	0.163**	0.305***	0.195***	0.184***	0.181**	0.119
	(0.0659)	(0.0887)	(0.0398)	(0.0457)	(0.0723)	(0.102)
K/L	0.230***	0.224***	0.202**	0.202**	0.171**	0.176*
	(0.0574)	(0.0415)	(0.0984)	(0.0837)	(0.0736)	(0.102)
Log IE_p	0.357**		0.474***		0.706***	
	(0.145)		(0.112)		(0.118)	
I_Both_p		-1.102***		0.0656		-0.0619
		(0.371)		(0.313)		(0.360)
I_tech_p		0.438		0.822**		2.141***
		(0.458)		(0.360)		(0.599)
I_nontech_p		-4.984***		-2.962		-4.505*
		(1.307)		(1.893)		(2.665)
Constant	12.20***	12.94***	11.28***	12.57***	11.11***	12.46***
	(0.460)	(0.305)	(0.313)	(0.156)	(0.320)	(0.262)
Ind dumm	yes	yes	yes	yes	yes	yes
Observations	281	281	928	928	569	569
R-squared	0.370	0.374	0.239	0.250	0.259	0.250

Note: Bootstrapped standard errors in parentheses (100 replications).
* Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level;
*** at the 1 percent level; no asterisk means the coefficient is not different from zero.

The finding that technological innovation is more important for the productivity of small and low-tech manufacturing, and traditional and small services than for KIBS and high-tech manufacturing firms could have important policy implications, as discussed in Section 8.

7. Extensions

This section discusses the impact of the existence of obstacles to invest in innovation activities on the decision to and the level of investment, and their possible impact through the innovation expenditure channel on the other equations of the model. In addition we will test the robustness of the results by including a proxy for the level of human capital of the firm in each of the equations of the model.

7.1. Financial Constraints and Lack of Qualified Workers and the Investment in Innovation Activities

In table 11 we run again the first stage of the model including two additional variables. Financial constraint is a dummy that takes value 1 if the firm considers that there are meso-economic (at market level, not necessarily at firm level) credit restrictions and they important or very important. Lack of qualified workers is also a dummy variable that takes value 1 if the firm considers that this is an important or very important obstacle to innovate.

As can be seen in table 11, there seems to be an effect of these constraints mainly in the level of expenditure and for some groups of firms. In the selection equation only financial constraint is significantly different from zero (and negative) and only for traditional service firms and small manufacturing firms. In the innovation expenditure equation, we can see that financial constraint matters for level of investment (with the expected negative sign) in the case of traditional service firms, and for all manufacturing firms and low-tech ones. A positive sign is found in the case of KIBS.

Lack of qualified workers impact negatively the innovation expenditure of traditional service firms and low-tech manufacturing firms. We can conclude that the existence of obstacles to innovate has some (but limited) impact on the innovation expenditure. To save space we are not presenting here the estimations of the innovation output equation and the productivity equation, but the results are similar to those presented in the previous section (these regressions are available upon request).

Table 11. Innovation Expenditure and the Existence of Constraints

	Services	KIBS	Traditional	Small	Ianufacturir	Hightech	Low Tech	Small
Variables\Dep. Var.	**Probability of investing in innovation IE>0**							
Exporter	0.372***	0.445***	0.323**	0.299***	0.0718	0.172	0.0591	0.137
	(0.0854)	(0.0262)	(0.132)	(0.104)	(0.0661)	(0.111)	(0.0881)	(0.131)
Foreign owned	0.133	-0.0220	0.283**	0.294	0.0835	-0.162	0.155	0.205
	(0.127)	(0.209)	(0.136)	(0.223)	(0.133)	(0.264)	(0.150)	(0.187)
Patent protection	1.474***	7.160***	1.331***	0.863**	1.884***	5.984***	1.742***	7.070***
	(0.323)	(2.297)	(0.360)	(0.417)	(0.520)	(0.155)	(0.579)	(0.413)
Public support	1.987***	7.753***	1.882***	2.064***	2.178***	1.615**	6.059***	11.85***
	(0.409)	(2.048)	(0.478)	(0.453)	(0.504)	(0.667)	(0.146)	(0.397)
Cooperation in R&D	1.276***	1.345***	1.198***	1.758***	1.501***	1.097***	2.042***	1.545***
	(0.172)	(0.400)	(0.216)	(0.335)	(0.200)	(0.168)	(0.347)	(0.384)
Market information	0.517***	0.443**	0.549***	0.315***	0.369***	0.367**	0.362***	0.231
sources (Info1)	(0.0901)	(0.183)	(0.0799)	(0.106)	(0.110)	(0.176)	(0.136)	(0.152)
Scientific sources	-0.130	0.0851	-0.258**	-0.0378	-0.262***	-0.489***	-0.185*	-0.371***
(Info2)	(0.119)	(0.118)	(0.116)	(0.0697)	(0.0988)	(0.156)	(0.109)	(0.130)
Public sources	0.0133	-0.0226	0.0227	0.224**	0.120	0.0598	0.126	0.251*
(info3)	(0.0873)	(0.0813)	(0.125)	(0.112)	(0.103)	(0.129)	(0.122)	(0.136)
Size	0.245***	0.275***	0.246***	0.253***	0.372***	0.441***	0.353***	0.438***
	(0.0232)	(0.0262)	(0.0314)	(0.0709)	(0.0255)	(0.0584)	(0.0236)	(0.0642)
Financial constraint	-0.112	0.0660	-0.200***	-0.0771	-0.108	-0.0774	-0.117	-0.219**
	(0.0789)	(0.174)	(0.0727)	(0.0972)	(0.0790)	(0.160)	(0.0979)	(0.109)
Lack of qualified workers	0.0680	-0.0181	0.0990	0.0251	0.122	0.0326	0.136	0.144
	(0.0799)	(0.0354)	(0.105)	(0.108)	(0.0916)	(0.0808)	(0.121)	(0.128)
Constant	-1.755***	-1.920***	-1.703***	-1.953***	-2.123***	-2.827***	-2.099***	-2.277***
	(0.0655)	(0.0921)	(0.0913)	(0.232)	(0.118)	(0.335)	(0.137)	(0.196)
	Log (Innovation expenditure)=Log IE							
Exporter	0.507	0.883	0.231	0.200	0.133	0.293	0.0472	0.252
	(0.318)	(0.683)	(0.249)	(0.379)	(0.0932)	(0.313)	(0.115)	(0.199)
Foreign owned	0.525**	0.499	0.580**	0.571**	-0.000508	-0.0301	0.0396	0.289
	(0.220)	(0.485)	(0.226)	(0.281)	(0.132)	(0.142)	(0.185)	(0.287)
Patent protection	0.473*	1.093***	0.117	0.0785	-0.339	-0.0215	-0.544	0.504
	(0.247)	(0.0802)	(0.300)	(0.607)	(0.348)	(0.131)	(0.573)	(0.421)
Public support	0.999	1.183	0.788	0.739	0.704***	0.462***	0.746**	1.056***
	(0.648)	(1.324)	(0.711)	(0.486)	(0.244)	(0.162)	(0.332)	(0.362)
Cooperation in R&D	0.983***	1.260**	0.875*	0.809	0.542***	0.599*	0.507**	1.066***
	(0.334)	(0.609)	(0.498)	(0.534)	(0.175)	(0.339)	(0.208)	(0.363)
Market information	0.384	0.754***	0.0890	0.143	0.328	0.0391	0.434*	0.254
sources (Info1)	(0.295)	(0.120)	(0.381)	(0.535)	(0.204)	(0.232)	(0.261)	(0.343)
Scientific sources	0.0767	0.386	-0.0770	-0.0835	-0.0167	0.155	-0.0748	-0.184
(Info2)	(0.154)	(0.297)	(0.160)	(0.180)	(0.195)	(0.291)	(0.207)	(0.237)
Public sources	0.377***	0.228**	0.420***	0.436*	0.150	0.145*	0.154	-0.0114
(info3)	(0.0647)	(0.102)	(0.0623)	(0.257)	(0.112)	(0.0856)	(0.149)	(0.209)
Financial constraint	-0.178	0.263*	-0.368***	-0.0551	-0.270**	-0.114	-0.331**	0.0105
	(0.139)	(0.136)	(0.0958)	(0.144)	(0.124)	(0.114)	(0.140)	(0.155)
Lack of qualified workers	-0.0648	-0.0662	-0.154**	-0.163	-0.187	0.0466	-0.278*	-0.125
	(0.0571)	(0.0610)	(0.0738)	(0.0999)	(0.125)	(0.168)	(0.150)	(0.134)
Constant	0.0233	-1.269	0.749*	1.173	2.337***	2.294***	2.435***	1.771***
	(0.587)	(1.031)	(0.422)	(1.195)	(0.303)	(0.267)	(0.475)	(0.475)
Industry dummies	yes	yes	yes	yes	yes	yes	yes	yes
Number of obs.	1,879	628	1,240	1,133	1,727	399	1,328	1,037
Log likelihood	-2,430	-865.4	-1552	-1214	-2267	-568.6	-1684	-1057
Dependence (ρ)	0.570**	0.837*	0.377*	0.109	-0.0490	0.0247	-0.0763	0.232
	(0.225)	(0.489)	(0.194)	(0.381)	(0.108)	(0.189)	(0.142)	(0.158)

*** p<0.01, ** p<0.05, * p<0.1. Errors clustered at 2 digit industry level.

7.2 Skilled Workers, Innovation, and Productivity

In this subsection we show the results of estimating all the equations with an additional variable: the share of skilled workers in the total workforce of the firm. This is a proxy for the level of human capital of the firm, and as such we expect it to have positive impacts on innovation and also on productivity. The next three tables summarize the results.

The main finding is that human capital is very important for innovation and productivity. In table 12 we can see that this variable is positive and significant in almost all regression, both in the selection equation and in the innovation expenditure equation. Therefore, it affects both the decision to invest in innovation activities and the amount to be invested. The other variables that are consistently important (and positive) for the decision to invest are, size, patent, cooperation in R&D and market sources of information; scientific sources of information continues to affect negatively the decision to invest.

Table 13 shows that skilled labor does not have an additional effect on the innovation output other than that coming through the innovation expenditure. On the contrary in some cases we find significant negative signs. Size and innovation expenditure, and patent to a lesser extent, continue to be the most important determinants of the innovation output.

In terms of productivity, the share of skilled labor is positive and significant in almost all equations where the innovation probability is used as a proxy for innovation (the only exception is for small service firms). The results found for the other variables, including the innovation variables are similar to those commented in previous sections.

Table 12. Innovation Expenditure and Human Capital

	Services	KIBS	Traditional	Small	Manufacturing	Hightech	Low Tech	Small
Variables\Dep. Var.	**Probability of investing in innovation IE>0**							
Exporter	0.303***	0.237***	0.314**	0.228	0.0514	0.160	0.0347	0.115
	(0.101)	(0.0711)	(0.137)	(0.143)	(0.0636)	(0.133)	(0.0819)	(0.124)
Foreign owned	0.0874	-0.0951	0.238**	0.221	0.0483	-0.198	0.112	0.154
	(0.113)	(0.192)	(0.119)	(0.208)	(0.123)	(0.221)	(0.142)	(0.184)
Patent protection	1.484***	7.332***	1.339***	0.823*	1.858***	5.987***	1.691***	6.810***
	(0.338)	(1.609)	(0.379)	(0.439)	(0.520)	(0.147)	(0.576)	(0.311)
Public support	2.010***	7.918***	1.904***	2.093***	2.164***	1.624**	6.007***	12.06***
	(0.426)	(1.571)	(0.514)	(0.450)	(0.509)	(0.679)	(0.163)	(0.537)
Cooperation in R&D	1.281***	1.382***	1.188***	1.740***	1.496***	1.101***	2.030***	1.544***
	(0.169)	(0.396)	(0.199)	(0.307)	(0.210)	(0.162)	(0.375)	(0.402)
Market information	0.541***	0.489**	0.565***	0.334***	0.361***	0.416**	0.332**	0.226
sources (Info1)	(0.0961)	(0.237)	(0.0779)	(0.0985)	(0.110)	(0.173)	(0.139)	(0.149)
Scientific sources	-0.179*	0.0277	-0.301***	-0.0793	-0.288***	-0.506***	-0.215**	-0.423***
(Info2)	(0.107)	(0.0604)	(0.114)	(0.0653)	(0.0949)	(0.154)	(0.100)	(0.113)
Public sources	-0.0141	-0.0464	0.00373	0.185*	0.108	0.0502	0.112	0.191
(info3)	(0.0865)	(0.0342)	(0.125)	(0.112)	(0.109)	(0.137)	(0.129)	(0.133)
Size	0.258***	0.297***	0.255***	0.259***	0.407***	0.483***	0.388***	0.493***
	(0.0179)	(0.0329)	(0.0244)	(0.0806)	(0.0282)	(0.0798)	(0.0194)	(0.0687)
Share skilled	0.701**	0.882***	0.547	0.730***	1.287***	1.147*	1.393***	1.217***
	(0.282)	(0.258)	(0.388)	(0.241)	(0.377)	(0.657)	(0.454)	(0.446)
Constant	-2.154***	-2.145***	-2.037***	-2.295***	-2.322***	-3.202***	-2.282***	-2.543***
	(0.145)	(0.0945)	(0.143)	(0.304)	(0.160)	(0.436)	(0.183)	(0.255)
	Log (Innovation expenditure)=Log IE							
Exporter	0.253	0.286	0.144	0.00371	0.155	0.273	0.108	0.227
	(0.231)	(0.398)	(0.268)	(0.377)	(0.115)	(0.317)	(0.143)	(0.214)
Foreign owned	0.432**	0.285	0.548**	0.519**	-0.00776	-0.0471	0.0326	0.228
	(0.168)	(0.371)	(0.242)	(0.251)	(0.131)	(0.117)	(0.190)	(0.291)
Patent protection	0.444*	0.996***	0.146	0.0255	-0.429	-0.0273	-0.662	0.436
	(0.234)	(0.139)	(0.324)	(0.555)	(0.354)	(0.149)	(0.569)	(0.414)
Public support	0.804	0.885	0.703	0.676	0.562**	0.348*	0.618*	0.934***
	(0.590)	(1.047)	(0.726)	(0.426)	(0.236)	(0.197)	(0.331)	(0.317)
Cooperation in R&D	0.892***	1.053**	0.916	0.742	0.423**	0.490	0.372*	0.938**
	(0.342)	(0.516)	(0.565)	(0.539)	(0.166)	(0.364)	(0.206)	(0.366)
Market information	0.367	0.837***	0.0697	0.133	0.240	0.0444	0.360	0.236
sources (Info1)	(0.279)	(0.155)	(0.390)	(0.504)	(0.210)	(0.193)	(0.277)	(0.341)
Scientific sources	-0.0944	0.274*	-0.289*	-0.252*	-0.0173	0.255	-0.142	-0.223
(Info2)	(0.144)	(0.147)	(0.166)	(0.134)	(0.215)	(0.253)	(0.217)	(0.229)
Public sources	0.279***	0.109***	0.351***	0.301	0.0569	0.0224	0.0805	-0.121
(info3)	(0.0565)	(0.0126)	(0.0467)	(0.217)	(0.107)	(0.0848)	(0.146)	(0.198)
Share skilled	1.772***	2.202**	1.453***	1.339***	1.477**	1.856***	1.338	1.767***
	(0.505)	(0.889)	(0.389)	(0.431)	(0.593)	(0.325)	(1.060)	(0.581)
Constant	-0.679	-1.392	-0.0269	0.719	2.253***	2.438***	2.224***	1.676***
	(0.682)	(0.908)	(0.677)	(1.210)	(0.384)	(0.334)	(0.551)	(0.526)
Industry dummies	yes	yes	yes	yes	yes	yes	yes	yes
Number of obs.	1,868	628	1,240	1,133	1,727	399	1,328	1,037
Log likelihood	-2407	-850.2	-1548	-1201	-2255	-559.9	-1680	-1049
Dependence (ρ)	0.513**	0.738*	0.530***	0.395***	-0.148	-0.0948	-0.155	0.196
	(0.211)	(0.408)	(0.0308)	(0.0519)	(0.131)	(0.269)	(0.169)	(0.157)

*** p<0.01, ** p<0.05, * p<0.1. Errors clustered at 2 digit industry level.

Table 13. Innovation Output and Human Capital

	Services								Manufacturing							
Variable	**All**	**KIBS**	**Traditional**	**Small**	**All**	**KIBS**	**Traditional**	**Small**	**All**	**High Tehc**	**Low Tech**	**Small**	**All**	**High Tehc**	**Low Tech**	**Small**
Dep var	**Technological inn**				**Non technological inn**				**Technological inn**				**Non technological inn**			
Exporter	-0.137	-0.0768	-0.00840	0.243*	0.155*	0.0174	0.217**	0.108	-0.310***	-0.778***	-0.221	-0.319	-0.260***	-0.815**	-0.117*	-0.589***
	(0.167)	(0.173)	(0.215)	(0.128)	(0.0851)	(0.127)	(0.0981)	(0.0981)	(0.104)	(0.290)	(0.140)	(0.197)	(0.0871)	(0.335)	(0.0653)	(0.130)
Foreign owned	-0.868***	-0.518	-1.225***	-0.919***	0.102	0.0682	0.0908	-0.0479	-0.0623	-0.242	-0.0357	-0.609***	-0.0754	-0.0866	-0.104	-0.251
	(0.188)	(0.329)	(0.325)	(0.327)	(0.115)	(0.0734)	(0.186)	(0.355)	(0.125)	(0.183)	(0.129)	(0.189)	(0.108)	(0.212)	(0.126)	(0.243)
Patent protection	0.452**	-0.0967	1.032***	0.852**	0.397	-0.646*	0.910**	0.362	2.291***	1.644***	2.720***	0.451	1.051***	0.975***	1.012***	0.439
	(0.230)	(0.385)	(0.324)	(0.428)	(0.399)	(0.385)	(0.368)	(0.422)	(0.343)	(0.109)	(0.464)	(0.432)	(0.160)	(0.0912)	(0.224)	(0.297)
Cooperation in R&D	-0.265	-0.0108	-0.658	-0.00138	0.344*	0.0537	0.338	0.543	0.249	-0.240	0.292	-0.515	0.164	-0.547	0.399**	-0.789***
	(0.343)	(0.0976)	(0.696)	(0.374)	(0.188)	(0.479)	(0.233)	(0.487)	(0.231)	(0.482)	(0.270)	(0.581)	(0.153)	(0.583)	(0.161)	(0.303)
Market information	-0.0895	-0.506***	0.435***	0.329***	0.495***	0.122	0.597***	0.242	-0.232	-0.0325	-0.439**	-0.104	0.0387	0.815***	-0.203*	-0.347*
sources (Info1)	(0.118)	(0.0894)	(0.0746)	(0.0706)	(0.110)	(0.562)	(0.117)	(0.184)	(0.151)	(0.200)	(0.204)	(0.185)	(0.147)	(0.164)	(0.106)	(0.185)
Scientific sources	-0.0142	-0.369**	0.370	0.259*	-0.00246	-0.167***	0.0152	0.308*	-0.253**	-1.412***	0.103	0.0237	-0.0732	-0.729*	0.0765	0.124
(Info2)	(0.0806)	(0.176)	(0.248)	(0.139)	(0.0753)	(0.0273)	(0.0745)	(0.165)	(0.110)	(0.331)	(0.109)	(0.190)	(0.0564)	(0.373)	(0.0518)	(0.171)
Public sources	-0.453***	-0.0642*	-0.758**	-0.326	-0.113	-0.139	-0.0677	-0.156	0.0575	0.0863	-0.00215	0.521***	0.254**	0.292	0.248	0.563***
(info3)	(0.162)	(0.0351)	(0.296)	(0.217)	(0.120)	(0.0955)	(0.156)	(0.212)	(0.0950)	(0.194)	(0.110)	(0.124)	(0.125)	(0.206)	(0.160)	(0.209)
Size	0.206***	0.179***	0.226***	0.217**	0.234***	0.242***	0.241***	0.247***	0.371***	0.381***	0.372***	0.434***	0.339***	0.384***	0.326***	0.386***
	(0.0134)	(0.0165)	(0.0130)	(0.0988)	(0.0191)	(0.0433)	(0.0265)	(0.0664)	(0.0350)	(0.128)	(0.0282)	(0.0902)	(0.0328)	(0.0689)	(0.0380)	(0.0699)
Log IE_p	1.685***	1.127***	2.137***	1.674***	0.458**	0.736*	0.393	0.812	2.663***	3.788***	2.570***	1.892***	0.705***	1.686	0.561*	1.351***
	(0.384)	(0.380)	(0.663)	(0.574)	(0.219)	(0.443)	(0.253)	(0.596)	(0.398)	(1.228)	(0.458)	(0.426)	(0.271)	(1.040)	(0.295)	(0.285)
Share skilled	-2.389***	-1.753*	-2.655**	-1.468	-0.417*	-1.050	-0.336	-0.554	-2.953***	-6.493***	-2.157***	-2.390***	0.0402	-2.296	0.644	-1.293*
	(0.870)	(1.030)	(1.164)	(0.908)	(0.230)	(0.772)	(0.250)	(0.720)	(0.697)	(2.348)	(0.768)	(0.879)	(0.577)	(2.298)	(0.614)	(0.751)
Constant	-0.942***	-0.359	-2.058***	-3.631***	-2.313***	-1.421**	-2.548***	-3.203***	-8.555***	-11.72***	-8.361***	-5.813***	-4.225***	-7.589***	-3.759***	-5.070***
	(0.312)	(0.469)	(0.254)	(0.274)	(0.0965)	(0.557)	(0.113)	(0.604)	(0.894)	(3.236)	(1.010)	(0.774)	(0.643)	(2.733)	(0.726)	(0.490)
Industry dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Number of obs.	1,868	628	1,240	1,133	1,868	628	1240	1,133	1,727	399	1,328	1,037	1,727	339	1,328	1,037
Log likelihood	-1800	-631.0	-1162	-965.4					-1575	-391.8	-1168	-782.3				
Independece (rho)	0.340***	0.602***	0.530***	0.558***					0.518***	0.529***	0.532***	0.607***				
	(0.0466)	(0.0292)	(0.0308)	(0.0237)					(0.0413)	(0.0671)	(0.0500)	(0.0713)				

Note: Bootstrapped standard errors in parentheses (100 replications).

* Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level; no asterisk means the coefficient is not different from zero with statistical significance.

Table 14.Productivity and Human Capital

Variable	Services		KIBS		Traditional		Small		Manufacturing		High Tech		Low Tech		Small	
	Dep. var=log(sales/employee)															
Size	-0.0390**	-0.164***	-0.137***	-0.310***	0.0117	-0.0983*	0.146**	-0.0446	0.204***	0.297***	0.172***	0.315***	0.217***	0.225***	0.204**	0.174*
	(0.0194)	(0.0382)	(0.0404)	(0.0774)	(0.0195)	(0.0517)	(0.0675)	(0.0996)	(0.0284)	(0.0434)	(0.0638)	(0.0731)	(0.0340)	(0.0608)	(0.0860)	(0.0945)
K/L	0.0704**	0.0695**	0.615	0.646**	0.0632**	0.0641**	0.0930***	0.0952***	0.199***	0.194***	0.228***	0.220***	0.183*	0.182**	0.162*	0.163*
	(0.0279)	(0.0315)	(0.376)	(0.317)	(0.0267)	(0.0284)	(0.0285)	(0.0285)	(0.0632)	(0.0564)	(0.0463)	(0.0568)	(0.0947)	(0.0817)	(0.0951)	(0.0961)
Log IE_p	0.487***		0.319***		0.513***		0.609***		0.490***		0.372**		0.463***		0.706***	
	(0.0924)		(0.122)		(0.105)		(0.186)		(0.105)		(0.156)		(0.0933)		(0.140)	
I_Both_p		1.144***		0.942		0.907**		1.086**		-1.115***		-1.084***		-0.109		-0.0142
		(0.270)		(0.619)		(0.376)		(0.461)		(0.357)		(0.359)		(0.489)		(0.487)
I_tech_p		0.945		0.0414		1.235		1.810*		1.100***		0.422		0.687**		1.690***
		(0.682)		(0.824)		(0.756)		(0.997)		(0.285)		(0.456)		(0.315)		(0.578)
I_nontech_p		3.826***		5.615***		3.152***		5.061***		-5.411***		-4.602***		-3.133		-5.541***
		(0.767)		(1.107)		(1.188)		(1.598)		(1.159)		(1.262)		(2.212)		(2.043)
Share skilled	0.0488	0.765***	0.294	0.811**	-0.0954	0.581***	-0.106	0.309	0.265	1.449***	0.0470	1.116***	0.682	1.422***	-0.466	0.956**
	(0.239)	(0.165)	(0.380)	(0.316)	(0.265)	(0.192)	(0.357)	(0.246)	(0.373)	(0.290)	(0.601)	(0.424)	(0.522)	(0.503)	(0.431)	(0.402)
Constant	12.66***	12.54***	12.88***	12.65***	12.36***	12.34***	11.17***	11.88***	11.15***	12.31***	12.00***	12.73***	11.15***	12.39***	11.05***	12.34***
	(0.142)	(0.175)	(0.223)	(0.237)	(0.148)	(0.192)	(0.260)	(0.254)	(0.263)	(0.183)	(0.446)	(0.258)	(0.247)	(0.183)	(0.367)	(0.309)
Ind dumm	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	1,093	1,093	343	343	750	750	562	562	1,209	1,209	281	281	928	928	569	569
R-squared	0.404	0.404	0.337	0.372	0.366	0.362	0.408	0.413	0.310	0.322	0.379	0.432	0.269	0.269	0.259	0.257

Note: Bootstrapped standard errors in parentheses (100 replications). * Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level; no asterisk means the coefficient is not different from zero statistical significance.

8. Conclusions and Policy Implications

In this paper the link between the investment in innovation activities, innovation outputs (technological vs. non-technological ones) and productivity in services and manufacturing is explored using CIS-like data for Uruguay. This is the first attempt to study these links for a developing country.

The size of firms, their cooperation in R&D activities, the use of public financial support, patent protection, and the use of market sources of information, are the variables that are more consistently associated with the decision to invest in innovation activities, both for services and manufacturing and across subsectors. This implies, if we interpret this correlation as causality, that policies to create R&D collaboration networks can have an important impact on the decision to invest in innovation activities, particularly for firms of relatively small size. Public financial support for innovation activities could also be important. The promotion of IPR, and patents in particular, could have also a positive impact on decision of carry out innovation activities. Finally, since market sources of information (clients, suppliers, etc.) are important, policies aimed to increase the communication between firms and these different agents can have an impact on innovation activities.

Other characteristics of firms, like to be an exporter or foreign owned, or the use of other sources of information (public or scientific) are not clearly linked (either on sign or significance) to the decision of invest in innovation activities. Financial constraints do not seem to be operating in most of the subsectors, after public financial support is taken into consideration, except perhaps for traditional service firms and small manufacturing firms.

In terms of the level of investment in innovation activities the only variable that appears to be significant in most of the regressions is R&D cooperation. Public financial support seems to be more relevant for manufacturing than for services. For KIBS market information, public information and patents are also relevant for the amount to invest in innovation activities. For traditional services, public sources of information are also important. Financial constraints seem to be operating in the case of traditional and low-tech firms inhibiting a higher level of investment.

The most relevant variables in the technological and non-technological innovation output functions are size and the level of investment in innovation activities. The level of investment is more important for technological innovations; this evidence is consistent with the fact that non-technological innovations arise from less formalized and more ad-hoc activities. This implies that the level of investment is more important for manufacturing innovations than for service innovations since manufacturing innovate more through technological innovations. Patent protection is also an important factor associated with innovation, but, as expected, is more relevant for technological innovations and manufacturing.

For productivity in services, innovations, both technological and non-technological, are very important. But non-technological innovations have a greater impact on services' productivity. The reverse is true for manufacturing; only technological innovating increases productivity. This heterogeneity could have important implications for policy. Incentives to innovation must be directed there where they have greater impact on productivity, and this implies to non-technological innovations in the case of service firms and to technological innovations in the case of manufacturing firms.

Technological innovations are more important for the productivity of small firms. Probably because they are far away from the technological frontier, improvements here generate bigger gains in productivity than in other firms. From the policy point of view, this could imply that facilitating small firms the access to new technology could be a way of generating a reduction in the productivity gap of this type of firms.

Finally, it is interesting to note the importance of level of skills of the workforce for innovation activities and for productivity. Since this is a factor that impacts across subsectors, it has policy implications that go beyond the innovation policy. It implies that the general level of education of the workforce is key element associated positively with innovation activities and greater levels of productivity, and therefore should be promoted.

References

Barcet, A. 2010. “Innovation in Services: A New Paradigm and Innovation Model”. Ch. 2 in Gallouj, F. and Dejallal, F. (eds.), Handbook of Innovation and Services. Cheltenham: Edward Elgar.

Baumol, W. 1967. "Macroeconomics of Unbalanced Growth: The Anatomy of Urban Crisis." American Economic Review, 1967, 57(June), pp. 415-26.

Blind, K., Evangelista, R. and Howells, J. 2010. “Knowledge Regimes and Intellectual Property Protection in Services: A Conceptual Model and Empirical Testing”. Ch. 15 in Gallouj, F. and Dejallal, F. (eds.), Handbook of Innovation and Services. Cheltenham: Edward Elgar.

Bogliacino, F., Lucchese, M. and Pianta, M. 2007. “Job Creation In Business Services: Innovation, Demand, Polarisation”. Working Papers Series in Economics, Mathematics and Statistics WP-EMS, ISSN 1974-4110.

Cainelli, G., Evangelista, R., and Savona, M. 2006. “Innovation and economic performance in services: a firm-level analysis.” Cambridge Journal of Economics. 30: 435–58.

Cohen, W., and Levinthal, D. 1989. “Innovation and Learning: The Two Faces of R&D.” The Economic Journal. 99(397): 569–96.

Crepon, B., Duguet, E., and Mairesse, J. 1998. "Research, Innovation and Productivity: An Econometric Analysis at the Firm Level." Economics of Innovation and New Technology 7(2): 115-58.

Crespi, G., and Zúñiga, P. 2010. “Innovation and Productivity: Evidence from Six Latin American Countries.” IDB Working Paper Series No. IDB-WP-18.

Criscuolo, C. 2009. “Innovation and productivity: estimating the core model across 18 countries.” Chapter 3 in OECD, Innovation in Firms a Microeconomic Perspective.

European Commission 2010.“Research Supporting Service Innovation”. Report from the workshop "Research supporting Service Innovation: a workshop for European SMEs" organised by the SME Unit, DG Research, Brussels.

European Commission 2009. “Promoting the Role of R&D in Services.” A report of the CREST OMC 3% Working Group, “R&D in Services”.

Europe Innova 2011.“Meeting the challenge of Europe 2020. The Transformative Power of Service Innovation”. Report by the Expert Panel on Service Innovation in the EU.

Evangelista, R. and Savona, M. 2003. “Innovation, employment and skills in services: firm and sectoral evidence”. Structural Change and Economic Dynamics, vol. 14, no. 4, 449–74.

Gallouj, F. and Dejallal, F. (eds.) 2010. Handbook of Innovation and Services. Cheltenham: Edward Elgar.

Gallouj, F., and Savona, M. 2008. “Innovation in services: a review of the debate and research agenda.” Journal of Evolutionary Economics. 19(2): 149–72.

Griliches, Z. 1979. “Issues in Assessing the Contribution of R&D to Productivity Growth,” The Bell Journal of Economics 10 (Spring 1979), 92-116.

Hall, B. 2011. "Innovation and Productivity," NBER Working Papers 17178.

Hertog, P. den 2010. Managing Service Innovation. Firm Level Dynamic Capabilities and Policy Options. PhD Thesis, University of Amsterdam, Amsterdam, the Netherlands. Kuusisto, 2008a.

Loof, H. 2004. "A Comparative Perspective on Innovation and Productivity in Manufacturing and Services," Working Paper Series in Economics and Institutions of Innovation 1, Royal Institute of Technology, CESIS.

Lopes, L. F., Godinho, M. M. 2005, ”Services Innovation and Economic Performance: Analysis at the firm level”, DRUID Working Paper No. 05–08.

Love, J. H., Roper, S., Hewitt-Dundas, N. 2010. “Service Innovation, Embeddedness and Business Performance“, Regional Studies, Vol. 44, Issue 8, pp. 983-1004.

Mairesse, J., and S. Robin 2010. “Innovation and Productivity: a Firm-Level Analysis for French Manufacturing and Services Using CIS3 and CIS4 data (1998-2000 and 2002-2004).” Paris, France: CREST-ENSAE.

Mansury, M.A., and J.H. Love. 2008. “Innovation, productivity and growth in US business services: A firm-level analysis.” Technovation 28: 52-62.

Masso, J. and P. Vahter 2012. “Innovation and Firm Performance in the Services Sector in Estonia.” Innovation, Technology, and Knowledge Management, Volume 15, pp 121-138.

OECD 2010. “The OECD Innovation Strategy: Getting a Head Start on Tomorrow”. Paris: OECD Publishing.

OECD 2009a. “Measuring Innovation: A New Perspective”. Paris: OECD Publishing.

OECD2009b. “Innovation in Firms: A Microeconomic Perspective”. Paris: OECD Publishing.

OECD 2005. “Promoting Innovation in Services.” Working Party on Innovation and Technology Policy. Paris: OECDP publishing.

OECD, 2001. ”Drivers of Growth: Information Technology, Innovation and Entrepreneurship” Science, Technology and Industry Outlook.

Pavitt, K. 1984. “Patterns of technical change: towards a taxonomy and a theory”, Research Policy, Vol. 3, No. 6, pp. 343-373.

Polder, M., van Leeuwen, G., Mohnen, P., Raymond, W. 2010. “Product, Process and Organizational Innovation: Drivers, Complementarity and Productivity Effects.” – UNU MERIT Working Paper Series, 2010, No. 2010-035.

Rubalcaba, L., and Gago, D. 2006. “Economic impact of service innovation: analytical framework and evidence in Europe.” Paper presented at the Conference on Services Innovation. Manchester, UK.

Sissons, A. 2011. “Britain’s Quiet Success Story. Business services in the knowledge economy” A Knowledge Economy programme report. The Work Foundation. Lancaster University.

Stelios, K., S. Aristotelis 2009. “Knowledge-Intensive Services, Innovation and Economic Performance: A Firm-Level Analysis.” Centre for Planning and Economic Research (Greece.

Tacsir, E. 2011. “Innovation in Services: The Hard Case for Latin America and the Caribbean”. IDB Discussion Paper No. IDB-DP-203.

Tether, B. 2004. “Do Services Innovate (Differently)?” CRIC Discussion Paper No 66. Manchester.

Uppenberg, K. and Strauss, H. (2010). “Innovation and productivity growth in the EU services sector”. European Investment Bank.

Appendix A: Descriptive statistics for the service sector at 2 digit level

Table A.1. Technological and non-technological innovation

Years			Technological Innovation					Non-Technological Innovation				
	N	CIIU	Product	Process	Innovative firms (1)	In-house Tech-Innov (2)	New to Market (3)	Organization	Marketing	Non-Tech Innovation (4)	Any Innovation (5)	Tech and Non-Tech Innovation (6)
All Service Industry	**1868**		**0.183**	**0.242**	**0.307**	**0.008**	**0.127**	**0.203**	**0.094**	**0.244**	**0.398**	**0.152**
							KIBS					
IT and related activities	91	72	0.571	0.440	0.670	0.044	0.407	0.286	0.143	0.330	0.714	0.286
Research and development	24	73	0.333	0.292	0.375	0.000	0.208	0.167	0.042	0.208	0.375	0.208
Business services	513	74	0.154	0.216	0.277	0.010	0.113	0.248	0.078	0.267	0.390	0.154
Subtotal	**628**		**0.221**	**0.252**	**0.338**	**0.014**	**0.159**	**0.250**	**0.086**	**0.274**	**0.436**	**0.175**
							Traditional Services					
Electricity, gas and hot water	17	40	0.18	0.41	0.41	0.00	0.18	0.41	0.12	0.41	0.59	0.24
Collection, purification and water distribution	6	41	0.17	0.50	0.50	0.00	0.00	0.33	0.33	0.50	0.50	0.50
Hotels and restaurants	203	55	0.10	0.13	0.17	0.00	0.09	0.12	0.07	0.15	0.25	0.08
Land transport	224	60	0.11	0.18	0.24	0.00	0.06	0.12	0.09	0.18	0.32	0.10
Water trasport	26	61	0.12	0.08	0.15	0.00	0.08	0.12	0.12	0.23	0.31	0.08
Air transport	17	62	0.12	0.12	0.18	0.00	0.12	0.00	0.00	0.00	0.18	0.00
Transport activities	261	63	0.13	0.23	0.26	0.00	0.10	0.22	0.11	0.27	0.39	0.15
Telecommunications	143	64	0.30	0.34	0.45	0.02	0.17	0.19	0.19	0.28	0.50	0.22
Rents of machinery and equipment	31	71	0.23	0.16	0.26	0.00	0.16	0.06	0.16	0.19	0.32	0.13
Activities related to human health	312	85	0.20	0.32	0.37	0.01	0.14	0.23	0.06	0.25	0.46	0.17
Subtotal	**1240**		**0.16**	**0.24**	**0.29**	**0.00**	**0.11**	**0.18**	**0.10**	**0.23**	**0.38**	**0.14**

(1) Product or process innovation, (2) Firms declare doing Internal R & D and tech inn,(3) New to Market product innovation, (4) Organization or marketing innovation,
(5) Technological or non-technological innovation, (6) Technological and non-technological innovation

Table A.2 Inputs and outputs from innovation

Years	CIIU	Inputs: Expenditure on innovation (1)	Inputs: R&D (2)	Inputs: Machinery Acquisition (3)	Inputs: Other Innovation activities (4)	Inputs: Firms that performed R&D	Inputs: Firms that performed R&D on a continuous basis	Outputs: Turnover from product innovations (5)	Outputs: Turnover from new to market product innovations
All Service Industry		1.71	11.24	27.03	61.74	10.65	13.97	11.35	4.27
KIBS									
IT and related activities	72	5.67	36.99	3.02	59.99	47.25	51.65	39.80	19.47
Research and development	73	1.70	14.93	6.52	78.54	16.67	20.83	17.00	9.17
Business services	74	1.24	11.82	13.10	75.08	11.11	14.42	9.10	3.96
Subtotal		1.90	17.94	10.47	71.60	16.56	20.06	13.85	6.41
Traditional services									
Electricity, gas and hot water	40	2.10	3.64	44.84	51.51	11.76	23.53	10.05	10.06
Collection, purification and water distribution	41	1.78	1.33	4.18	94.50	16.67	33.33	16.50	16.67
Hotels and restaurants	55	0.90	5.85	37.67	56.48	3.94	5.91	6.35	1.43
Land transport	60	2.05	3.99	53.07	42.94	3.13	4.91	8.44	1.96
Water trasport	61	0.25	23.46	3.15	73.39	11.54	15.38	6.31	3.46
Air transport	62	0.03	16.67	0.00	83.33	5.88	11.76	11.76	0.00
Transport activities	63	1.45	6.06	27.12	66.82	7.28	9.58	7.87	2.86
Telecommunications	64	2.28	13.74	30.73	55.53	17.48	20.98	18.45	6.57
Rents of machinery and equipment	71	3.31	5.13	50.09	44.78	3.23	6.45	10.48	4.52
Activities related to human health	85	1.60	6.95	39.44	53.61	8.97	13.78	11.78	3.31
Subtotal		**1.61**	**7.35**	**36.63**	**56.02**	**7.66**	**10.89**	**10.09**	**3.19**

(1) Total expenditures on innovation (as a % of total turnover), (2) Expenditure on R&D (internal) as a % of total expenditure on innovation

(3) Expenditure on machinery acquisition as a % of total expenditure on innovation, (4) Expenditure on the rest of innovation activities as a % of total expenditure on innovation, (5) Share of product innovation in turnover

Table A.3. Policy relevant variables

	CIIU	International markets (1)	Co-operated with clients, providers (2)	Co-operated in R&D (3)	Co-operated with Universities or Gov. (4)	Public Support (5)	Applied for patents (6)
All Service Industry		0.067	0.912	0.136	0.031	0.021	0.013
				KIBS			
IT and related activities	72	0.280	0.912	0.297	0.110	0.055	0.055
Research and development	73	0.035	0.917	0.375	0.125	0.042	0.000
Business services	74	0.047	0.938	0.135	0.027	0.012	0.008
Subtotal		0.080	0.933	0.167	0.043	0.019	0.014
				Traditional			
Electricity, gas and hot water	40	0.001	0.824	0.353	0.176	0.000	0.059
Collection, purification and water distribution	41	0.002	0.833	0.333	0.000	0.000	0.000
Hotels and restaurants	55	0.074	0.936	0.039	0.015	0.010	0.000
Land transport	60	0.078	0.888	0.031	0.013	0.031	0.004
Water trasport	61	0.327	0.885	0.115	0.000	0.000	0.000
Air transport	62	0.199	0.882	0.000	0.059	0.000	0.000
Transport activities	63	0.088	0.847	0.069	0.015	0.011	0.008
Telecommunications	64	0.046	0.895	0.196	0.035	0.049	0.028
Rents of machinery and equipment	71	0.000	0.935	0.032	0.032	0.000	0.032
Activities related to human health	85	0.000	0.942	0.244	0.035	0.029	0.019
Subtotal		0.060	0.902	0.120	0.025	0.023	0.012

(1) Share of firms that export, (2) Share of firms that co-operated with clients or providers (3) Share of firms that co-operated on innovation activities, (4) Share of firms that co-operated with Universities/Higher education or government research institutes, (5) Share of firms that received public financial support for innovation
(6) Share of firms that applied for one or more patents

Appendix B. Definition of Variables

Variable	Source	Description
Tech innovation	IS	Dummy=1 if firm introduced product or process innovation in the period of the survey
Non-technical Innovation	IS	Dummy=1 if firm introduced organizational or marketing innovation in the period of the survey
Productivity	IS	log(sales per employee). End of year of survey.
Innovation expenditure	IS	R&D expenditures and other innovation expenditures such as design, installation of machinery, industrial engineering and embodied and disembodied technology (capital and machinery, patents, patent and trademark licensing, disclosures of know-how, and computerand other technical services), and design, marketing, and training, per employee. End of Year survey.
Firm size	IS	log number of employees. Year-end of survey
Foreign ownership	IS	Dummy=1 if foreign capital greater than 10% Year-end of survey.
Patent	IS	Dummy=1 if firm appliedfor patent in the period of the survey
Exporter	IS	Dummy=1 if firms exports. Year-end of survey.
Public support	IS	Dummy=1 if firm obtained financial support from government in the period of the survey
Cooperation in R&D	IS	Dummy=1 if firm was linked to some institution (exeption) for design or R&D in the period of the survey
Market information sources (Info1)	IS	Dummy=1 if importance of market sources (suppliers, clients, competitors, consuting firms, experts) was very important or important in the period of the survey
Scientific sources (Info2)	IS	Dummy=1 if importance of scientific sources (universities, public research center, technological institutions) was very important or important in the period of the survey
Public sources (info3)	IS	Dummy=1 if importance of public sources (journals, patents, magazines, expositions, associations, databases, Internet) was very importantor important in the period of the survey
Share skilled	IS	Share of skilled employment. End of year
Employment R&D	IS	Log of total employment in R&D (formal and informal units). End of year.
K/L	EAS	Total fixed assets over employees. Year-beginning survey
Financial constraint	IS	Dummy=1 if financial constraint was very important or important obstacle to innovate in the period of the survey
Lack of qualified workers	IS	Dummy=1 if the lack of qualified workers was very important or important obstacle to innovate in the period of the survey