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## **DETERMINANTS OF INNOVATION AND PRODUCTIVITY IN MEXICAN FIRMS: AN ANALYSIS UNDER THE SYNTHESIS APPROACH**

# **Determinants of innovation and productivity in Mexican firms: An analysis under the synthesis approach**

## **Abstract**

This paper presents an analysis of the effects of innovation activities on innovation output and productivity for the services sector. We build on the theoretical framework of synthesis approach to understand innovation in services better by comparing it with manufacturing. We rely on a new taxonomy of sectoral patterns of innovation presented in 2008 by Castellacci (2008). Based on data from the latest available Mexican innovation survey, we explore the determinants of technological innovation and the impact of innovation on firm's productivity in Mexico. Our results indicate that firms' structural and behavioral factors, such as size, openness strategy, use of public funds, and exporting behavior, increase the propensity to invest in innovation. Our results also show that firms with higher innovation intensity tend to show a superior innovation performance, compared to firms that invest poorly in innovation. Our results also show important differences across sectors and indicate that more dynamic services firms have similar patterns to those in manufacturing. In terms of policy implications, this study highlights the importance of promoting innovation as the basis for improved productivity of services firms in Mexico. More specifically, policy interventions need to enhance both the number of services firms that perform innovation, and the intensity of those innovation activities.

**JEL classifications:**L8,O12,O14,O31, O33,O40

**Key words:** Innovation, Productivity, Innovation in services, Innovation in manufacturing, Innovation survey, Mexico.

# 1 Introduction

The understanding of the effect of R&D and innovation on firms' productivity has gained attention from scholars and policy makers over the last two decades. After the seminal study of Crépon, et al. (1998) several other studies have made important contributions on the positive effect of R&D, and innovation on firm's productivity with specific focus on manufacturing industries (Crespi and Zuñiga 2010). In recent years, the analysis of innovation in the services industries has gained increased attention (Barras 1986; Barras 1990), and the interest to identify the integration between manufacturing and services industries has been in the agenda of several scholars. Barras (1986) discussed an inverse product life cycle to present the innovation patterns in services industries, and Castellacci (2008) suggested a new sectoral taxonomy that combines manufacturing and services industries to show the importance of inter-sectoral knowledge exchange between industries. Understanding the interaction between services and manufacturing industries is crucial to have a more integrated view of the characteristics of innovation and how the integration between different industries contribute to the development of technology or non-technological innovations.

This study endorses the growing interest in challenging traditional conceptualizations of services as users of technology, and characterized by slow productivity growth, from an already low productivity base relative to other sectors of the economy (Pavitt, 1984; Miozzo and Soete, 2001). Rather, we endorse recent contributions to the literature calling for new conceptualizations of sectoral patterns, and a deeper understanding of their heterogeneity, dynamics and interactions with other sectors of economic activity (DTI 2007; Rubalcaba and Gago, 2006; Tacsir and Guaipatin, 2011). Expanding on the seminal work of Barras (1986, 1990), who introduced the inverse product innovation cycle, where services benefit from innovation in the manufacturing sector, but they also contribute to the development of those innovations, Casetellacci (2008) suggests a new taxonomy that combines the analysis of manufacturing and services industries highlighting the interaction between them.

This study aims to understand the effect of R&D and innovation on firms' productivity in the services sector comparing it with manufacturing. Based on firm level data from Mexico, we study the determinants of innovation, and innovation intensity, and finally, we analyze if and how innovation sways firms' performance, as measured in terms of labor productivity. We focus our analysis on the service sector, stressing the importance of vertical linkages and inter-sectoral

knowledge exchanges between manufacturing and services to better understand innovation in the service sector. We build our analysis following Castellacci's (2008) taxonomy of firms, which distinguishes between advance knowledge providers (AKP), mass production goods (MPG), supporting infrastructure services (SIS), and personal goods and services (PGS). Based on Crépon, Duguet and Mairesse (1998), we performed a three-stage econometric CDM model across the four different sectors.

Three main hypotheses are elaborated along this paper. The first hypothesis explores the component that firms engage in innovation activities and they invest in those innovation activities, but the engagement and intensity varies across sectors. We address that hypothesis in equations 1 and 1.1 in our econometric model. The second hypothesis relevant to this study is that firms across the different sectors innovate differently. This study seeks to identify the differences between services and manufacturing regarding the decision to engage in innovation activities and the decision to invest in them.

The third hypothesis addressed in this study is that innovation intensity has a positive impact on the innovation output and on firms' productivity, but this impact also varies across sectors. We test this hypothesis along a CDM model. Equations 1.2.1 and 1.2.2 will indicate the impact of innovation intensity, ownership, export experience, and patent applications on innovation output. Equation 1.3 and 1.3.1 will test the impact of innovation output and innovation investment on firms' productivity respectively, we also identify the effect of patent applications and non-technology innovation.

The remaining parts of this paper are organized as follows. Section two presents a brief overview of recent contributions to literature on innovation determinants and sectoral patterns of innovation. Section three introduces the methodology used in this study, including the main data sources, descriptive statistics and description of the econometric model. Section four describes the main aggregates that characterize manufacturing and services sectors in Mexico, including GDP and employment, and presents and discusses the results from our econometric model. Finally, section five concludes.

## **2 Literature review**

### **2.1 Innovation determinants and its impact on productivity**

It has been recognized that innovation is a key driver of productivity and economic growth. Boosting innovation is becoming even more important now for countries to be able to remain competitive in a globalized economy. Identifying the different modes of learning and investigating a) how firms learn and b) how different forms of learning are related to output remains an important component for policy making. Jensen et al (2007), and Chaminade and Vang (2008) argue that innovation policies might only be supporting one type of learning and not other types prevalent in firms. Fostering innovation at the firm level can contribute to increased high technology and high value added products or services.

Identifying the main determinants of business innovation, and the effect of innovation expenditure on innovation output and productivity remains of significant importance, and has been of great interest in the last decades. Since their work Crepon, Duguet and Mairesse in 1998, several studies followed the analysis of the most important determinants for innovation and their potential impact on innovation output and productivity. Mohnen et al. (2006) and Griffit et al. (2006) using community innovation surveys (CIS) they performed a comparative analysis across several European countries, and identified specific differences regarding innovation determinants and their effects on innovation output and productivity for the manufacturing sector. Crespi and Zuniga (2012) also analyzed the role of innovation on firms' productivity for several Latin American countries, and Benavente (2006) analyzed it for Chile in particular. All of them find that for the manufacturing sector, innovation determinants and their effects on innovation output and productivity are context specific. These works have made an enormous contribution in theoretical and empirical discussions regarding the most important determinants of innovation and their potential effects on innovation output and productivity (Mairesse and Mohnen 2010).

What these studies lack is a broader analysis of the service sector: services and manufacturing behave differently and have specific innovation patterns. Barras (1986) indicated that services industries follow a reverse innovation cycle, where their innovations are fed by innovations in the manufacturing sector, and that at the same time, innovations in services also contribute to innovations in manufacturing. Castellacci (2008) contributed to this discussion emphasizing the complementarity between services and manufacturing to innovate. In this regard, studies that focus on the innovation determinants and their effects have raised the

importance of analyzing the service sector individually or performing comparative analysis between services and manufacturing. Using the CIS for UK Polder (2009) compared manufacturing and services, and found that both technological innovations and non-technological innovations are important to foster firms' productivity. In particular for services sectors, non-technological innovation seems to play a more important role in firms' productivity. Further work is needed to analyze both services and manufacturing industries, understanding also the heterogeneity within these two sectors. A second gap in this field of literature refers to a more detailed analysis of the impact of public support on the determinants for innovation activities, and their role for innovation output and productivity. Government support refers to direct or indirect support to innovation. According to the OECD (2012) direct financing instruments include credit loans and guarantees, repayable advances, competitive grants, technology consulting services and extension programs, innovation vouchers, equity financing and venture capital investments etc. Indirect financing instruments include tax incentives on R&D and innovation (R&D tax credits, R&D tax allowances and payroll withholding tax credit for R&D wages). A third gap is related to the identification of how different types of innovation output have an impact on firm's productivity.

## **2.2 Three theoretical approaches to understand innovation processes in the services sector**

The development of taxonomies for the study of sectoral patterns of innovation has mainly focused on manufacturing industries, but some recent studies (Castellacci 2008) have raised the importance of also considering the service sector in the development of taxonomies for patterns of innovation.

In the last decades, the services sector has increased its importance as the largest contributor to employment and gross domestic product (GDP) in both developed and developing countries (Evangelista, 2000; Hauknes, 1996, Miles et al., 1995). This notwithstanding, the study of innovation in services is relatively new, yet in full development (Drejer, 2004; Evangelista, 2000; Hauknes, 1996; Miles et al., 1995). Gallouj and Weinstein (1997) indicate that the analysis of innovation in services faces two main difficulties. First, theoretical developments have been based primarily on the study of technological innovation in manufacturing activities (Gallouj and Weinstein, 1997; Evangelista, 2000; Drejer, 2004). Second, there is the need to consider the

specificities of services activities. In particular, the immaterial nature of services hinders the possibilities of measuring innovation through traditional methods (R&D investment), while limiting the capacity to track improvements or changes in product-services (Gallouj and Weinstein, 1997). Gallouj and Weinstein (1997) also assert that these difficulties are the starting point of two complementary approaches to studying innovation in Services.

Hauknes (1996) calls the first approach *technology based approach*, also known as *assimilation approach* (Drejer, 2004; Tether and Howells, 2007), which focuses on understanding the role of technology in services (introduction of equipment and systems). Consequently, the study of innovation in services builds on the same conceptual framework and definitions used to research the manufacturing sector (technological and product innovation). The approach likewise uses the same instruments for measuring innovation in manufacturing, which Djellal and Gallouj (2000) called *subordinated surveys*. Studies in this tradition have made important contributions to understanding the impact of technology adoption in the services sector, especially in information and communication technologies.

Djellal and Gallouj (2000) and Tether and Miles (2000) criticize the assimilation approach arguing that it tends to ignore that innovation in services has specific characteristics; they suggest that in addition to technological innovations, the definition of innovation should encompass various forms of non-technological innovations including organizational and market innovations. In their critic to the assimilation approach, Djellal and Gallouj (2000) likewise decry the limited usefulness of subordinated surveys –innovation surveys applied to the manufacturing sector, particularly the Community Innovation Survey (CIS). In their view, it is better to develop custom surveys, better tuned to understand the specificities of innovation in Services. Tether and Miles (2000) adopt a more radical view; they conclude that the approaches underpinning the CIS, and thus the Oslo Manual, exclude important elements of non-technological innovations; moreover, they are limited for an understanding of the real dynamics of innovation and its relationship with economic performance. And yet, empirical studies based on the assimilation approach, which use subordinated surveys, suggest that the differences between services and manufacturing are not significant. Based on panel data of firms, Mannheim, Germany, and Ebling (2000) found that the main determinants of exports by services firms in the region are variables associated with innovation activities, particularly technological innovations, as well as variables related to human capital. A comparative analysis of technological innovation in services

and manufacturing by Sirilli and Evangelista (1998) used data from two surveys –from 1993-1995 for services firms, and 1990-1992 for manufacturing firms. The authors found that innovations in both sectors had more similarities than differences. Evangelista (2000) shares this conclusion; arguably the differences are more of degree than of kind of innovation. The similarities found in these studies, among others, are not a demonstration that the assimilation approach is the most appropriate to understand the dynamics of innovation in Services, since these similarities may be the direct cause of the approach itself because it does not consider the potential differences resulting from other types of innovation (Drejer, 2004; Tether and Howells, 2007).

A second approach is the *Services-oriented approach* or *demarcation approach*, (Gallouj and Weinstein, 1997; Hauknes, 1996; Drejer, 2004). This approach emphasizes the specificities of both innovation and production processes in Services. It rejects the centrality of technological innovation; rather, it highlights the role of organizational innovation and knowledge-based services innovation, where R&D and “*hard technologies*” are of relatively lower importance as compared to manufacturing sectors (Tether and Howells, 2007). This approach is linked to the use of *autonomous surveys* (Djellal and Gallouj, 2000) to identify the dynamics and specificities of innovation in Services. In that sense and by that definition, this approach does not compare the specificities of services innovation with those exhibited in the manufacturing sector. Consequently, a major shortcoming of this approach is the potential for errors in the inference of what is or what is not specific to the innovation processes in the services sector that it attempts to characterize (Drejer, 2004). Djellal and Gallouj’s (2001) is an example of this problem; the analysis confirms the importance of users in the development of innovations and the multiplicity of actors involved in the innovation process, and the interactive nature of innovation. Arguably, all these are common elements of innovation processes in manufacturing. Noteworthy in this debate is that the heterogeneous nature of services implies that even if innovation in certain services activities may show strong similarities with innovation in manufacturing, some others clearly show some specific characteristics (Hauknes, 1996).

Today innovation scholars interested in services innovation recognize the importance of both technological and non-technological innovation; they stress the interactions and complementarities existing between these two types of innovations. This consensus is made

explicit by a third approach to study innovation in Services, one that Hauknes (1996) called *integrated approach* or *synthesis approach* (Tether and Howells, 2007; Drejer, 2004). This perspective highlights the growing complexity and multidimensional nature of innovation in both services and manufacturing. Attention is increasingly drawn to the complementarities and convergence between the production of goods and services. The synthesis approach argues that understanding innovation in services provides an important input to understand innovation processes in other sectors, including manufacturing. It recognizes the importance of both technological and non-technological innovation, especially organizational and market, and points at the interactions and complementarities between these two types of innovation (Tether and Howells, 2007). Hence, there is a shifting focus for research, from technology to knowledge, and away from the study of individual firms to understand value chains or networks, locating services and manufacturing as interconnected parts in a system. Knowledge intensive business sector (KIBS) are an example, as they can be seen as technological or knowledge intermediaries in the innovation system (Miles et al., 1995). The integrative perspective is relatively recent and it has not been applied in many innovation surveys (Drejer, 2004). Some relevant contributions in this tradition include Gallouj and Weinstein (1997), Coombs and Miles (2000), Hollenstein (2003), Drejer (2004), Hipp and Grupp (2005), Tiri et al. (2006), Leiponen and Drejer (2007), Castellacci (2008) and Peneder (2010).

### **2.3 Different types of patterns of innovation in the services sector**

Soete and Miozzo (1989) propose a typology based on Pavitt (1984), which allowed the identification of different patterns of innovation in services; the typology was perhaps the first step to incorporate the study of innovation in the services sector. Since then several studies have emerged including Den Hertog and Bilderbeek (1999), Evangelista (2000), Tether and Hipp (2000), Sundbo and Gallouj (2000), Hollenstein (2003), Hipp and Grupp (2005), Hipp and Herstatt (2006), De Jong and Marsili (2006), Hortelano and González-Moreno (2007), Miles (2008), Castellacci (2008). Evangelista (2000) developed a similar typology based on an innovation survey of 19,000 services firms with twenty employees or more, collected for the period 1993-1995. Applying factor analysis to categorize services innovation, the author identified four patterns of innovation. By contrast, based on a cluster analysis of 2,731 services firms included in the 1999 Swiss Innovation Survey, Hollenstein (2003) identified five patterns

of innovation in Services. Both Soete and Miozzo's (1989) and Hollenstein (2003) have been heavily criticized for their strong compliance with *assimilation-like/technology based* approaches; and hence for failing to sufficiently capture non-technological innovations.

From an alternative perspective, Hipp and Grupp (2005) introduced the *network-based innovation* classification, which includes two kinds of activities. On the one hand, *scale intensive and physical network intensive sectors* (transport and wholesale trade); and on the other hand, *information-intensive networks sectors* (communication, finance and insurance services). This classification consists of technical services, R&D and software, which are identified with KIBS. The authors argue that, in general, existing typologies of innovation in services use traditional, narrow definitions of innovation; consequently, they stress the need for new concepts and indicators helping to understand the dynamics of innovation in services. At the same time, Hipp and Grupp (2005) suggest the need to study innovation processes in manufacturing and services based on a common analytical framework.

Consistent with a *synthesis approach*, Tether and Takhar (2008) develop a typology of innovation that involves both manufacturing and services. By looking at the firm's orientation towards innovation, the authors classify firms according to their innovative features, including their main source to access technologies, and the firm's perception of its core innovation competences. The authors conducted a quantitative analysis to identify three types of innovation modes: (i) Product-Research (PR) mode, (ii) Process Technologies (PT) mode, and (iii) an Organizational Cooperation (OC) mode.

In this line, Castellacci (2008) developed a typology that combines manufacturing and services within a common analytical framework. This typology builds on the Fourth Community Innovation Survey (CIS4, 2002-2004) for a sample of manufacturing and services in 24 European countries. These data are combined with information on the economic performance of these sectors from the OECD-STAN database for the period 1970-2003.

Castellacci (2008) expanded on Miozzo and Soete's typology stressing that because manufacturing and services are two very interrelated parts of an economy, it should be possible to combine them within the same framework. In order to do so, the author proposes a new typology that captures some of the ideas from Miozzo and Soete (2001); at the same time, it emphasizes

the fundamental role played by the relationships among different types of service and manufacturing industries, namely the extent and intensity of vertical linkages and inter-sectoral knowledge exchanges that tie together producers, suppliers and users of new technologies. Castellacci thus seeks to provide ‘an integrated view of the characteristics that innovation takes in manufacturing and in service industries’ (Castellacci, 2008, p. 979). In building the typology, the author considered two main characteristics of industrial sectors, namely, their function in the economic system as providers and/or recipients of advanced products, services and knowledge; and the dominant innovative mode that characterizes the technological activities of each different sector. The latter denotes the technological regime and innovative trajectory of the sector. Hence the author identifies four types of firms based on their specific features and the importance of vertical ties for innovation.

### **3 Methodology**

#### **3.1 Data sources**

This study draws on firm level data collected from the Mexico’s Survey on Innovation and Technology Development (ESIDET by its Spanish acronym). The questionnaire includes an innovation survey with questions based on the Oslo Manual. This particular study is based on information from ESIDET 2010, which collected information corresponding to the period 2008-2009. ESIDET’s geographical coverage is national, and sectoral coverage includes the productive sector, particularly the manufacturing and services sectors, excluding the maquila industry. ESIDET uses a stratified random sample for each of the industries according to the OECD classification. The raw data consists of a representative sample of 4,156 firms, 2,455 manufacturing, and 1,701 services firms. The ESIDET 2010 survey includes a set of 1,271 firms that conduct research and technological development and have been granted public support in order to undertake R&D or other innovation-related activities. Thus there is a bias regarding large firms and innovative firms that have received public support for innovation.<sup>1</sup>

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<sup>1</sup> Notwithstanding its limitations, the sampling frame of ESIDET 2010 has improved compared to previous events; the target group has been expanded from including only firms with 50 employees or more, to including firms with 20 employees or more.

ESIDET 2010 follows the North American Industry Classification System (NAICS) 2007. We identified the equivalence between NAICS and the International Standard Industrial Classification (ISIC) Rev. 3.1, as this second classification is based on the technology intensity of firms which is necessary to conduct this study<sup>2</sup>

To classify services firms and compare them with manufacturing firms, we build our discussion using the taxonomy developed by Castellacci (2008), where he classifies firms as advance knowledge providers (AKP), mass production goods (MPG), supporting infrastructure services (SIS), and personal goods and services (PGS).

ESIDET 2010 contains specific modules that capture technology innovation in Mexico. The modules identify firm's general characteristics, human resources, internal R&D, external R&D, expenditure in science and technology services, and technology transfer. The survey also contains information about awareness of and participation in government led programs in support for R&D and innovation, international cooperation for R&D, technological innovation, the firms' perception regarding factors that motivate innovation, and the firms' assessment of the barriers they confront to innovate.

### 3.2 Firm characteristics

This section builds on data from ESIDET 2010; it presents some descriptive statistics of services and manufacturing firms in Mexico following Castellacci's (2008) taxonomy. Following this taxonomy, approximately 44% of firms are personal goods and services (PGS), 35% of firms are mass production goods (MPG), while only 11% of firms are infrastructural services (SIS) and 9% are advance knowledge providers (AKP). In addition, manufacturing firms: specialized suppliers manufacturing (SSM), science based manufacturing (SBM), scale intensive manufacturing (SIM), and supplier dominated goods (SDG), account for 66% of the firms in the sample; while services firms knowledge intensive business services (KIBS), network infrastructure services (NIS), physical infrastructure services (PIS), and supplier-dominated services (SDS), account for the remaining 33%.

Table 1 and Table 2 present some descriptive statistics regarding the technological regimes and technological trajectories of firms across the different sectors. For technological regime Castellacci (2008) includes innovativeness and opportunity levels, cumulativeness conditions,

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<sup>2</sup> Mexico's National Institute for Statistics, Geography and Informatics (INEGI by its Spanish acronym) publishes the equivalence between ISIC Rev. 3.1 and NAICS 2007.

appropriability means, and external sources of opportunities. For innovativeness and opportunity levels we included indicators about level of innovation and amount of innovation investment. We considered the intensity of filing patents as a measure of appropriability. For external sources of knowledge, we differentiated between market, scientific and public sources.

There is also a set of features that indicate firm's technological trajectories, such as dominant type of innovation, type of expenditure, and strategies adopted in the innovative process (Castellacci 2008). For the dominant type of innovation we relied on information about technological and non-technology type of innovation. We also included the type of investment on innovation activities. Based on ESIDET (2010), firms in Mexico feature a total of eight possible innovation activities, namely the purchase of machinery and equipment linked to innovation, acquisition of other external technologies linked to innovation activities, the provision of training linked to innovation activities, the preparatory processes leading to the launching of innovations into the market, R&D, industrial design or prototyping of new or improved processes or products, purchase of software, the logistics underpinning the introduction of a new services or of new or improved delivery systems to the market.

Regarding the technological regimes, the data show different levels of innovativeness, appropriability, and access to different sources of information across the different sectors. MPG show the highest level of innovativeness, and investment on innovation activities and R&D. Even though appropriability through patents is low in the Mexican context, MPG firms present the highest levels of appropriability. Regarding the sources of information, MPG uses more extensively Market information. It is important to mention that market sources of information are the most widely used across the four different sectors. AKP uses more extensively universities as sources of information than the other three sectors. We also observed differences in terms of services and manufacturing, for most of the services subsectors, the innovativeness level showed a lower performance than for manufacturing subsectors, with exception of KIBS. KIBS is the only subsector in services that presented higher levels of innovativeness in terms of new to the world innovations, and expenditure in innovation activities. Their performance on innovativeness and expenditure on innovation activities is comparable to manufacturing firms.

Regarding technological trajectories we also observed differences across sectors, and across manufacturing and services firms. Regarding the type of innovations, firms in general reported a higher output of non-technological innovations than of technological innovations. This

difference is even sharper for most of the services firms, in particular for NIS and PIS firms. On the other hand, KIBS have a more similar distribution of technological and non-technological innovations to manufacturing firms. MPG is the sector with a higher level of technological innovation, both product and process, but it also showed a higher level of marketing innovation. Within MPG, SBM firms showed a higher level of these types of innovations in comparison with SIM firms. On the other hand, AKP and SIS firms showed a higher level of organizational innovations.

**Table 1. Technological Regimes**

	AKP	KIBS	SSM	MPG	SBM	SIM	SIS	NIS	PIS	PGS	SDG	SDS
Innovative firms (%)	18	17	20	22	27	19	6	9	5	11	14	4
New to Country (%)	11	12	10	12	16	9	3	6	1	5	7	2
Expenditure on innovation (%)	1.62	1.79	1.39	2.23	3.18	1.67	0.27	0.37	0.10	1.32	1.52	0.86
R&D (%)	2.89	2.09	4.13	16.33	24.13	7.41	10.93	7.48	30.68	5.66	4.70	9.62
Appropriability through patents (%)	3.74	3.91	3.48	4.12	4.79	3.65	0.81	1.45	0.43	1.28	1.88	0.20
INFOPublic (%)	43.88	41.90	46.96	41.90	45.10	39.67	38.17	40.58	36.75	39.69	41.53	36.38
INFOMarket (%)	64.29	58.66	73.04	69.29	70.59	68.39	63.71	69.57	60.26	63.16	64.23	61.23
INFOScience (%)	28.23	27.93	28.70	22.83	25.49	20.97	19.62	23.91	17.09	19.20	19.38	18.89
No. firms	294	179	115	1,117	459	658	372	138	234	1,406	903	503

Source: Authors based on information contained in ESIDET 2010

**Table 2. Technological trajectories**

	AKP	KIBS	SSM	MPG	SBM	SIM	SIS	NIS	PIS	PGS	SDG	SDS
Product (%)	15.65	14.53	17.39	19.87	24.40	16.72	5.11	7.97	3.42	8.75	11.30	4.17
Process (%)	10.54	10.61	10.43	11.55	11.11	11.85	3.49	5.07	2.56	5.41	6.98	2.58
Organization (%)	56.80	58.66	53.91	48.61	49.46	48.02	50.81	63.04	43.59	44.67	44.96	44.14
Marketing (%)	23.81	24.02	23.48	29.72	35.08	25.99	26.08	31.16	23.08	27.74	29.79	24.06
Machinery and equipment %	11.90	11.17	11.30	9.22	9.59	8.97	4.30	5.07	3.85	5.26	7.09	1.99
Other external technology %	3.06	4.47	0.87	1.79	1.96	1.67	1.08	2.90	0.00	1.85	1.99	1.59
Training %	7.14	8.38	5.22	7.61	9.15	6.53	2.42	5.07	0.85	3.34	3.99	2.19
R&D %	6.80	5.03	9.57	11.64	15.25	9.12	1.88	1.45	2.14	3.91	4.76	2.39
Logistics Innovation launch %	2.38	3.91	0.00	3.13	3.49	2.89	1.08	2.90	0.00	1.64	2.10	0.80
Design %	3.06	2.79	3.48	4.66	4.14	5.02	0.27	0.00	0.43	1.92	2.88	0.20
Software purchase %	6.12	5.59	6.96	3.40	3.49	3.34	1.34	2.90	0.43	2.63	2.77	2.39
Delivery systems %	1.36	2.23	0.00	1.79	1.53	1.98	1.08	2.17	0.43	1.64	2.10	0.80
Turnover from new to market product innovations	5.88	5.7	6.17	6.85	7.45	6.44	1.56	3.73	0.27	2.77	3.56	1.34
No. firms	294	179	115	1,117	459	658	372	138	234	1,406	903	503

Source: Authors based on information on ESIDET 2010

We also observed important differences in the type of innovation expenditure across sectors. The sectors that invest most on innovation activities are AKP and MPG, on the other hand SIS and PGS do not invest as much in innovation activities. There are also differences on the type of innovation investment between AKP and MPG, on the one hand, AKP has preference to invest on machinery and equipment, external technology and software, while MPG firms invest mainly on training, R&D, logistics and design. It is also important to note that a higher percentage of manufacturing firms invest in innovation activities, in particular those associated with machinery and equipment, R&D and training. A lower percentage of services firms invest in innovation activities, and they mainly invest in machinery and equipment. The descriptive statistics confirm the relatively lower importance of investment in R&D to capture innovation performance of services firms; however, the share of KIBS firms reporting investment in R&D is the highest in services firms. Regarding turnover from new to market product innovations, manufacturing firms show a higher turnover.

### **3.3 Model for determinants of innovation and productivity in firms**

To conduct this analysis, we perform a three-stage Heckman (1978) model, where the first stage focuses on the main factors underpinning the likelihood that a firm will invest in innovation activities, and the intensity of these activities. This first stage corrects for selection bias, as not all firms in the services sector engage in innovation activities. The second stage focuses on the innovation output, measured as the number of product or process innovations that the firm performed in a given year. The third stage studies the effects of innovation on productivity in the services sector. Based Castellacci (2008), we classified the firms in the ESIDET 2010 database according to their technological intensity, either in advance knowledge providers (AKP), mass production goods (MPG), supporting infrastructure services (SIS), or personal goods and services (PGS).

The Heckman model for the first stage of the analysis includes two equations. The first equation indicates the main determinants for innovation activities. The second equation indicates the intensity of those activities. The dependent variable for equation 1 ( $\text{dummyEXCAP}_i$ ) is a dummy variable that equals 1 if the firm performs any type of innovation activity. More specifically, we do not rely only on the performance of R&D as the original CDM model, but we also include the following innovation activities: investment in machinery and equipment,

acquisition of technologies, training linked to innovation activities, acquisition of software, investment in industrial design and prototyping, and investment for services innovation. We use a broader spectrum of innovation activities, as R&D may not be the preferred mechanism underpinning innovations in services firms (OECD, 2009). Some firms may find it difficult to track and record R&D expenditures, or even consider the funds used for innovation.

The independent variables for equation 1 are the set of explanatory variables that might influence the likelihood that a firm engages in any of those innovation activities. The explanatory variables ( $x_i$ ) account for exports, ownership, size, patents, and the use of public funds for innovation, for instance:

$$(1) \quad \text{dummyEXCAP}_i = x_i b, j_{i1}, \dots, j_{in} + e_i$$

The dependent variable for the second equation of stage 1 (1.1) ( $\log\text{EXCAP}_i$ ) is the innovation effort per employee expressed in logarithms. We build this proxy variable by calculating the expenditures on innovation activities per worker in case the firm reports such expenditures. More specifically, we use those innovation activities that imply financial investments by the firm, namely the development of own technology, the acquisition of machinery and equipment linked to innovation, the purchase of other external technologies linked to innovation, the payment for training linked to innovation, the conduction at R&D, or the purchase of software. The vector of explanatory variables ( $x_{ii}$ ) account for exports, ownership, patents, the use of public funds to innovate, openness strategy, sources of information, and barriers to innovation, for instance:

$$(1.1) \quad \log\text{EXCAP}_i = x_{ii} b, j_{i1}, \dots, j_{in} + e_i$$

The innovation production function indicates the innovation output of firms, we used a poisson regression analysis in this second stage. Innovation output is measured by the number of product/services innovations (*prodserv\_launch*) or process innovations (*process\_launch*) that a firm reports in a given year. The independent variables are the predictor from equation 1.1 (*EXCAP\_eq11*), firm size, exports, and ownership.

$$(1.2.1) \quad \text{prodserv\_launch}_i = \text{EXCAP\_eq11}_i + x_i b, j_{i1}, \dots, j_{in} + e_i$$

$$(1.2.2) \text{ process\_launch}_i = \text{EXCAP\_eq11}_i + x_i b_j + j_{il}, \dots j_{in} + e_i$$

The last equation indicates the impact of innovation on firm's performance, measured as productivity per employee. Productivity measured in terms of sales per employee and expressed in logarithms is the dependent variable. The independent variables are the predictors from equation 1.2.1 and 1.2.2, firm size, and non-technological innovation.

$$(1.3) \text{ logproductivity09}_i = \text{innov\_eq12}_i + a_i c_b + j_{il}, \dots j_{in} + e_i$$

We also performed a robustness analysis by performing the same analysis using the predictors from equation 1.1 as expressed below.

$$(1.3.1) \text{ logproductivity09}_i = \text{EXCAP\_eq11}_i + a_i c_b + j_{il}, \dots j_{in} + e_i$$

The control variables are the four classifications as indicated by Castellacci's (2008) taxonomy. In total we calculated the model across five different subsamples, the first model cuts across the complete database where we had 3,189 observations. The second model captures the behavior of AKP with 294 observations. The third model captures the behavior of MPG with 1,117 observations. The fourth model focuses on SIS with 372 observations. The last model focuses on PGS with 1,406 observations. Table 3 indicates the descriptive statistics for the variables used in the model.

**Table 3. Descriptive Statistics for the Three Stages Model**

Variable	Description
<b>Dependent variables</b>	
Innovation intensity (logEXCAP_employees)	Natural logarithm of the firm's total investment on innovation activities per employee
Innovation activities (dummyEXCAP)	1 if the firm reports any type of innovation activities; 0 otherwise
Technological innovation output (innov_dummy)	1 if the firm reports product or process innovation; 0 otherwise
Product or service innovation output (prodserv_launch)	Total number of product or service innovations
Process innovation output (process_launch)	Total number of process innovations
Firms' productivity (logproductivity_09)	Natural logarithm of the firm's productivity measured as sales per employee in 2009
<b>Independent variables</b>	
Firm size 08 (log_firm_labor08)	Natural logarithm of the firm's total labor force in 2008
Firm size 09 (log_firm_labor09)	Natural logarithm of the firm's total labor force in 2009

Variable	Description
Ownership (firm_fdi_20)	1 if the firm reports more than 20% foreign capital in the firm's total capital; 0 otherwise
Exports (log_export08)	Natural logarithm of the firm's total exports in 2008
Patent applications (patent_sol08_dummy)	1 if the firm reports any patent application in 2008; 0 otherwise
Public funds for innovation (u_innov_fund_dummy)	1 if the firm access any type of public fund for innovation; 0 otherwise
Openness strategy (open_strategy)	1 if the firm reports any type of collaboration for innovation; 0 otherwise
Market sources of information (INFOMarket)	1 if the firm considers market sources of information highly important (suppliers, clients, competitors, consulting firms and experts); 0 otherwise
Scientific sources of information (INFOScience)	1 if the firm considers scientific sources of information highly important (universities and public research centers); 0 otherwise
Public sources of information (INFOPublic)	1 if the firm considers market sources of information highly important (Internet, journals, patents, publications, fairs or meetings); 0 otherwise
Cost barriers (cost_factor)	1 if the firm experienced cost barriers to innovation and reported it as highly important; 0 otherwise
Knowledge barriers (knowledge_factor)	1 if the firm experienced knowledge barriers to innovation and reported it as highly important; 0 otherwise
Market barriers (market_factor)	1 if the firm experienced market barriers to innovation and reported it as highly important; 0 otherwise
Regulation barriers (Regulation_factor)	1 if the firm experienced regulation barriers to innovation and reported it as highly important; 0 otherwise
Predictor for innovation intensity (EXCAP_eq11)	Predicted value from equation 1.1
Predictor for product/service innovation (innov_prodserv_eq12test)	Predicted value from equation 1.2.1 (product or service innovation)
Predictor for process innovation (innov_process_eq12test)	Predicted value from equation 1.2.2 (process innovation)
Organizational innovation (innov_organization)	1 if the firm incorporated organizational innovations; 0 otherwise
Market innovation (innov_market)	1 if the firm incorporated market innovations; 0 otherwise
Advance knowledge providers (akp)	1 if the firm operates in a traditional services activity; 0 otherwise
Mass production goods (mpg)	1 if the firm operates in a traditional services activity; 0 otherwise
Supporting infrastructure services (sis)	1 if the firm operates in a traditional services activity; 0 otherwise
Personal goods and services (pgs)	1 if the firm operates in a traditional services activity; 0 otherwise

Source: own elaboration

The results from the models are reported on Table 4 and Table 5. A detailed discussion of the results is provided in the following section.

## **4 Empirical findings. Determinants of innovation and productivity**

### **4.1 The decision to invest in innovation and the intensity of innovation expenditure**

Results from equations (1) and (1.1) indicate the determinants of likelihood to engage in innovation activities, and the innovation intensity expressed as the log of innovation activities per worker.

Our results across the four different models show interesting patterns regarding the motivation of firms to engage in innovation activities and the determinants that influence their innovation intensity.

**Table 4 Determinants of Innovation and Productivity for AKP and MPG**

VARIABLES	AKP						MPG					
	1.1	1	1.2.1	1.2.2	1.3.2	1.3.1	1.1	1	1.2.1	1.2.2	1.3.2	1.3.1
log_firm_labor08		-0.0667**						-0.0301*				
		-0.0329						-0.0171				
log_firm_labor09			0.481***	-0.00501	-0.193***	-0.207***			0.0466***	0.124***	-0.397***	-0.299***
			-0.0155	-0.0182	-0.0566	-0.0564			-0.00423	-0.0106	-0.041	-0.0371
firm_fdi_20	-1.235*	-0.624***	-1.465***	-1.223***			-0.695**	-0.200**	1.066***	0.591***		
	-0.726	-0.21	-0.127	-0.164			-0.335	-0.0972	-0.026	-0.0556		
log_export08	0.0219	0.0618***	0.0629***	0.0718***			0.0381	0.0359***	0.0470***	0.0171***		
	-0.0522	-0.0167	-0.0044	-0.00801			-0.0322	-0.0081	-0.00208	-0.00501		
patent_sol08_dummy	3.198**	6.665					0.569	8.358				
	-1.47	-507,837					-0.742	-650,772				
u_innov_fund_dummy	1.830**	1.052***					1.287**	0.969***				
	-0.814	-0.191					-0.562	-0.0996				
open_strategy	1.940***						1.350***					
	-0.573						-0.329					
INFOMarket	-0.174						0.289					
	-0.61						-0.355					
INFOScience	0.259						-0.114					
	-0.53						-0.362					
INFOPublic	-0.458						0.33					
	-0.526						-0.323					
cost_factor	1.156**						0.286					
	-0.562						-0.333					
knowledge_factor	-0.967*						0.0309					
	-0.556						-0.331					
market_factor	-0.101						-0.236					
	-0.539						-0.335					
regulation_factor	0.075						-0.0861					

	-0.512						-0.34					
EXCAP_eq11test		0.460***	0.295***		0.0748			0.846***	0.640***		0.387***	
innov_prodserv_eq12test		-0.00742	-0.0208		-0.0607			-0.00848	-0.0185		-0.0423	
					-0.00555						0.0264***	
					-0.00439						-0.00958	
innov_process_eq12test					0.185***						0.307***	
					-0.0534						-0.0535	
innov_organization					0.330*	0.313					0.113	0.0638
					-0.199	-0.2					-0.0893	-0.0895
innov_market					0.0067	0.0299					0.272***	0.205**
					-0.226	-0.231					-0.0982	-0.0984
prodserv_innov_employee					-2.188	-1.842					0.545***	0.500***
					-1.567	-1.616					-0.161	-0.16
process_innov_employee					1.171	1.047					0.401	0.402
					-1.863	-1.9					-0.377	-0.375
athrho	0.555						0.15					
	-0.469						-0.275					
Insigma	0.951***						1.053***					
	-0.142						-0.0424					
Sigma					1.428***	1.457***					1.249***	1.242***
					-0.0619	-0.0632					-0.0285	-0.0283
Constant	-1.147	-0.261	-0.781***	0.386***	6.759***	7.143***	-0.0455	-0.616***	0.589***	-1.427***	8.567***	8.013***
	-1.384	-0.201	-0.11	-0.118	-0.382	-0.378	-1.11	-0.12	-0.0345	-0.0836	-0.266	-0.251
Observations	294	294	294	294	266	266	1,117	1,117	1,117	1,117	961	961

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

Source: Author's own with information from ESIDET 2010.

**Table 5 Determinants of Innovation and Productivity for SIS and PGS**

VARIABLES	SIS						PGS					
	1.1	1	1.2.1	1.2.2	1.3.2	1.3.1	1.1	1	1.2.1	1.2.2	1.3.2	1.3.1
log_firm_labor08		0.0564***										
		-0.0219										
log_firm_labor09			-0.148***	-0.266***	-0.411***	-0.576***		-0.00644	-0.123***	0.319***	-0.393***	-0.409***
			-0.0127	-0.0103	-0.0687	-0.0635		-0.0188	-0.00254	-0.0177	-0.0331	-0.0315
firm_fdi_20	1.868	0.358	-0.309**	0.543***			-0.0183	-0.277*	0.344***	1.136***		
	-1.344	-0.252	-0.129	-0.084			-0.466	-0.142	-0.0189	-0.0609		
				0.0291**					0.0394**			
log_export08	0.0595	0.0331	0.0107	*			0.039	0.00794	*	-0.140***		
	-0.117	-0.0218	-0.00934	-0.0071			-0.043	-0.0101	-0.00162	-0.0058		
patent_sol08_dummy	6.585**	1.66E+13					1.643					
	-2.951	0					-1.407					
u_innov_fund_dummy	3.527**	0.720***					1.211					
	-1.394	-0.231					-0.977					
open_strategy	0.89						0.813*					
	-0.763						-0.422					
INFOMarket	-0.114						0.283					
	-1.114						-0.392					
INFOScience	-0.867						-0.457					
	-0.956						-0.435					
INFOPublic	0.0105						-0.21					
	-0.691						-0.386					
cost_factor	1.285**						-0.289					
	-0.641						-0.383					
knowledge_factor	0.624						-0.278					
	-0.787						-0.415					
market_factor	0.106						-0.0211					
	-0.759						-0.417					
regulation_factor	-0.341						-0.324					

	-0.747						-0.437						
EXCAP_eq11test		0.360***	0.287***		0.113*		0.906***	0.957***	1.091***			0.387***	
		-0.0117	-0.00988		-0.062		-0.0733	-0.00645	-0.0204		0.0106**	-0.049	
innov_prodserv_eq12test				-0.281***							*		
				-0.108							-0.00255		
innov_process_eq12test				0.302***							-0.0154		
				-0.055							-0.019		
innov_organization				0.156	0.136						0.164**	0.167**	
				-0.195	-0.206						-0.0827	-0.0817	
innov_market				0.514**	0.461**						0.217**	0.174*	
				-0.222	-0.231						-0.0927	-0.0919	
prodserv_innov_employee				1.322	1.106						0.0971**	0.0893**	
				-0.803	-0.836						-0.0382	-0.0378	
process_innov_employee				46.81	47.92						-1.47	-1.829	
				-36.61	-38.18						-2.23	-2.207	
athrho	2.001***						-0.147						
	-0.688						-0.419						
lnsigma	1.563***						0.976***						
	-0.202						-0.0603						
Sigma				1.546***	1.613***						1.264***	1.252***	
				-0.0604	-0.063						-0.0257	-0.0255	
Constant	8.070***	-1.281***	3.449***	3.685***	8.437***	10.46***	0.733	-2.024***	1.623***	-2.886***	8.216***	8.164***	
	-1.214	-0.159	-0.0631	-0.0569	-0.505	-0.618	-1.881	-0.143	-0.0191	-0.133	-0.235	-0.227	
Observations	372	372	372	372	328	328	1,406	1,406	1,406	1,406	1,210	1,210	

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

Source: Author's own with information from ESIDET 2010.

We found that the most important determinants to engage in innovation activities are related to firm's size and ownership, previous experience regarding exports, and the use of public funds to innovate.

Firm's size is an important determinant to engage in innovation activities, but we observe important differences for manufacturing and services firms. On the one hand, for the case of manufacturing firms in MPG, and also AKP, our findings show that smaller firms are more prone to engage in innovation activities; while on the other hand, for services firms in SIS, we observe that larger firms are more prone to engage in innovation activities. Benavente (2006), Crespi and Peirano (2007) and Crespi and Zuñiga (2010) found that larger manufacturing firms are more prone to engage in innovation activities.

Our results suggest that firms in Mexico, in particular those classified as AKP and MPG, with foreign ownership show a lower propensity to engage in innovation activities, and also show lower expenditure on these activities. This is a different finding from previous discussions (Crespi and Zuñiga, 2010; Girma and Görg, 2005). In particular Crespi and Zúñiga (2010) identified for other Latin American countries that those firms with more than 10% of foreign ownership are more prone to engage in innovation activities and also that they have a higher rate of innovation intensity. This finding can be explained by the fact that multinational companies seldom invest in R&D in developing countries (Chaminade and Vang, 2008; Crespi and Zuñiga, 2010; Pietrobelli and Rabellotti, 2009), or if they do invest in R&D, this is usually geared to adapt existing products to the local market (Lasserre, 2011; Kuemmerle, 1997). Our results also point out that foreign ownership has no distinctive effect on the decision to engage in innovation activities, or in the intensity of these activities for SIS and PGS firms. This result needs to recognize the differences between manufacturing and services firms. Concerning PGS and services firms in SIS, foreign ownership in these firms might not play an important role on the decision to innovate, as they might not follow an active innovation strategy.

Export experience plays an important role for firms to engage in innovation activities for services and manufacturing, in particular for AKP and MPG. These results are on line with those by Ebling (2000), Zúñiga et al. (2007), who found that an active export behavior has positive effects on firms' innovation performance. The marginal effect is about 0.04 for the entire sample, 0.6 for AKP, 0.03 for MPG and PGS. On the other hand, export experience showed a marginal effect for innovation intensity, but only for the complete sample. Patent intensity also shows an

important and positive effect for innovation intensity, in particular for AKP and SIS firms. Crespi and Zúñiga (2010) found that manufacturing firms that have patents have a higher propensity to invest in innovation activities in different Latin American countries. Our results partially confirm those findings, as AKP and SIS firms that have filed for patents have a higher propensity to invest more in innovation activities.

Our results suggest that accessing publicly funded programs in support to innovation and a firm's openness strategy seem to play an important role for both the decision to engage in innovation activities and the innovation intensity. The use of public funds to innovate is a high and significant determinant for innovation activities across all the models analyzed. In addition, those firms in AKP, MPG, and SIS, which receive public funds to innovate invest significantly more in innovation activities than firms that did not receive these funds. Similar results were obtained by Crespi and Zúñiga (2010). Our results show that firms in AKP that received public funds invest 1.8 more on innovation activities than firms that did not receive such benefits. MPG firms that receive public funds for innovation invest about 2.8 more than those firms that did not receive public funding to innovate. Firms in SIS reported the highest effect, as those firms that receive public funds invest about 3.5 more than firms that did not receive such funds. In contrast, the use of public funds to innovate did not show a significant impact on the innovation intensity for firms in PGS.

An openness strategy to innovate plays an important role for innovation investment across firms in AKP, MPG, and PGS. This result suggests that these firms are capturing the effects of spillovers from other sources of knowledge. This result is in line with those by Veugelers and Cassiman (1999), Laursen and Salter (2004), and results reported by OECD economies (OECD 2009), where firms that have openness strategies for innovation activities usually have higher innovative performance. Crespi and Zúñiga (2010) found that for the Latin American case, only a few countries reported that an openness strategy to collaborate impacts their investment on innovation activities, but for the particular case of Mexico an open strategy has a significant effect on innovation intensity for both manufacturing and services, but this effect is stronger for services firms. On the other hand an openness strategy did not show any effect on the innovation intensity for SIS firms. This result points out an important element identified also by Crespi and Zúñiga (2010), which is related to the limited knowledge exchange among actors, and might

express the limited capacity of SIS firms to take advantage of the knowledge available to compete based on their innovation intensity.

Barriers to innovation associated with cost are important for investing in innovation activities, in particular for AKP and SIS. On the other hand barriers associated with knowledge seem to play a positive effect to invest in innovation activities for AKP firms, this result can be associated to the need to engage in an openness strategy to search for knowledge that is not available at the firm level.

#### **4.2 The impact of innovation investment on the probability of technological innovation**

We also estimated a knowledge production function (eq. 1.2.1 and 1.2.2) using a probit regression. The probit regression indicates the elasticity of the dependent variables on the innovation output. Our results show that the effects for innovation intensity are statistically significant across all our models for product/services innovation and process innovation, but we can observe some differences across sectors. For AKP, it has an impact of 0.4 for product/service innovation and 0.3 for process innovation. For MPG it reported an impact of 0.8 for product/service innovation and 0.6 for service innovation. For SIS it reported the lowest impact, of about 0.3 for product/service innovation, and 0.2 for process innovation. Innovation intensity showed the highest impact for the case of PGS it reported an impact of 1.0 for both types of innovation. These results confirm those by Crespi and Zúñiga (2010), Griffith et al. (2006) and Raffo, Lhuillery and Miotti (2008), and indicates that firms with higher innovation intensity per employee also show higher probability to introduce product or process innovation.

Our results show interesting results for the impact of firm size on product and process innovation. For AKP and MPG our findings confirm those by Benavente (2006) and Crespi and Peirano (2007), who have claimed that larger firms are more prone to benefit from economies of scale related to production and R&D, benefiting also from a larger pool of human resources. On the other hand, smaller firms indicate to have a higher effect on product and process innovation for SIS firms.

Foreign ownership represents an important determinant for the probability of producing technological innovation. FDI has a positive effect for product and process innovation across the

entire sample, but it brings some differences across sectors. The presence of FDI on AKP firms is significant and negative for product and process innovation. FDI also show to be significant and negative for product innovation in SIS firms, but it has a positive effect for process innovation for SIS. On the other hand, FDI has a positive effect on product and process innovation for firms in MPG and PGS. These results help to complement those by Crespi and Zuniga (2010), as they found a positive effect of FDI on innovation output without differentiating for the type of innovation.

Our results on previous export experience help to understand better the effect of exports on product innovation and process innovation. As discussed previously by Zúñiga et al. (2007), export behavior conditions the technological performance of firms in Mexico. In this study we found that export experience is indeed an important determinant for innovation, but it has differentiated effect for product and process innovation across the different sectors. Our results show that previous export experience is an important determinant for process innovation, in particular for AKP, MPG, and SIS firms, but export experience has a negative effect for process innovation for PGS firms. On the other hand, it is interesting to note that export experience has a negative effect for product innovation for firms in AKP and MPG, but it has a positive effect on PGS firms. This result is interesting and helps us to understand the complementarities between product and process innovation across different sectors. First, for sectors that are not dominated by consumers, such as MPG, SIS, and AKP engaging in exporting activities forces them to be more competitive, thus incorporating process innovation, more than product innovations. On the other hand, when sectors dominated by the customer engage in exporting activities they are force to innovate in products, as they need to adapt them to other markets.

### **4.3 Determinants of productivity**

Finally, we estimated the determinants of productivity in equation 1.3, measured in term of sales per employee. Our results show a highly significant and positive impact of innovation performance on firm's productivity in most of the models. For AKP, our results showed no effect of investment in innovation activities on the overall firm's productivity. On the other hand, our results were positive and significant for MPG, SIS and PGS. There is an effect of 0.38 for MPG and PGS, and 0.11 for SIS.

In this case, firm size is an important determinant for firms' productivity. Our result suggests that smaller firms have higher productivity measured in terms of sales per employee. This result contributes to those by Crespi and Zúñiga (2010), as they did not identify impact of firms' size on productivity. This result suggests that smaller firms might be more flexible to introduce changes that are needed in a changing environment, having a positive effect on its productivity. Non-technological innovation is also an important determinant for productivity, especially market innovation. In this regard, Tether and Howells (2007) recognize the importance of both technological and non-technological innovation, pointing to the existence of complementarities between these two types of innovation. In particular, market innovation is significant for most of the models. The elasticity reported by MPG is 0.20, the elasticity reported by SIS 0.46, and the elasticity reported by PGS is 0.17. On the other hand, organizational innovation is only significant for PGS. These results point out the existence of complementarities between technological and non-technological of innovation that contribute to foster firms' productivity, and confirm those by Crespi and Zúñiga (2010).

## **5 Conclusions**

The main aim of this study was to understand the effect of innovation activities on innovation output and productivity in the services sector. To better understand innovation in the service sector, we explored the importance of vertical linkages and inter-sectoral knowledge exchanges between manufacturing and services using Castellacci's (2008) taxonomy.

The AKP, MPG, SIS and PGS sectors in Mexico differ in terms of their technological regimes and technological trajectories. This study has documented the limited innovation and behavior of firms in Mexico in general; the bulk of firms in our sample tended not to actively engage in innovation activities and whenever they did so, it was only at a very limited scale. This situation tends to reaffirm the view that a large amount of firms in Mexico prefer imported technologies to the development of internal technological capabilities (OECD, 2012). This situation is differentiated across sectors, AKP and MPG showed a better performance than firms in SIS and PGS. From a capacity building perspective, the missed opportunities for firms in Mexico would conform to what D'Este et al. (2012) characterize as a situation of 'withdrawal' and "failure without learning". The innovation management literature documents that innovation projects may need not succeed in order to provide useful lessons for the firm. The above also

suggests that opportunities for policy learning are reduced because the activity being targeted by public intervention is so severely restrained by the agents. At the end, they are the ultimate intended beneficiaries of the intervention. The need to enhance the intensity and productivity of innovation activities carried out by firms in Mexico is persistent. At the same time, science, technology and innovation authorities must strive to enlarge the base of firms that are active innovators as part of a long-term, sustained business strategy. Notwithstanding the recent improvements recorded at the level of micro interventions via specific instruments to promote innovation (FCCyT, 2006; OECD, 2012), the governance of Mexico's national system of innovation requires significant improvement in order to attract private sector investment in innovation.

### **Determinants for innovation and its impact on productivity**

The results from the model on innovation determinants and the impact of innovation on productivity show that innovation intensity has a strong impact on the innovation output and productivity, and innovation output also demonstrates a high impact on firm's productivity, but there are important differences across sectors.

Important determinants for the decision to innovate and innovation intensity are related to structural, behavioral and performance factors. However, important differences arise across AKP, MPG, SIS and PGS sectors, supporting our first hypothesis. There are similar patterns between AKP and MPG; AKP is integrated by KIBS (services) and SSM (manufacturing), while MPG is integrated by SBM and SIM, both manufacturing. Thus we can argue that these two sectors are more dynamic in engaging in innovation activities and investing in those innovation activities. On the other hand, SIS and PGS have different patterns regarding engaging in innovation activities and investment in those activities.

More specifically, firm size has been associated with higher R&D investment (Benavente, 2006; Crespi and Peirano, 2007), due to high economies of scale on innovation; however, our results suggest that firm size is not an important determinant for the decision to innovate or for innovation intensity for AKP and MPG. But firm size is an important determinant for the decision to innovate for SIS firms. Low levels of FDI, and export experience play an important role for the decision to engage in innovation activities for AKP and MPG, but they seem not to impact SIS and PGS. The use of public funds for innovation seems to play an important role for

firms, with exception of those firms in PGS. In general, firms with an open strategy to access different sources of information show to have higher innovation intensity levels. Our findings also report that most of the innovation barriers have no effect on innovation intensity, only barriers related to innovation cost seem to be an important determinant for those AKP and SIS industries. D'Este et al. (2012) argue that firms that report no innovation activities are more likely to assess barriers to innovation as more important than firms with innovation activities. This might explain the non-significant result of innovation barriers on innovation intensity.

Regarding the effect of innovation intensity, our results also confirm the second hypothesis, as firms across different sectors innovate differently in terms of product/service innovation and process innovation. Our results also suggest that AKP and MPG follow similar patterns in terms of firm size and export experience, but there are important differences regarding FDI. Lower levels of FDI play an important role on higher product and process innovation output for AKP and SIS, on the other hand, higher levels of FDI seem to play an important role for product and process innovation output for MPG and PGS. It is interesting to note that export experience show a different effect across sectors, indicating the complementarity between product and process innovation. We can argue that for sectors that are not dominated by consumers, such as MPG, SIS, and AKP, engaging in exporting activities forces them to be more competitive, thus incorporating process innovation. On the other hand, when sectors dominated by the customer engage in exporting activities they need to adapt these products to new markets, forcing them to innovate in products. These results contribute to those by Crespi and Zuniga (2010), and help to understand the interaction and differences between product and process innovation in manufacturing and services sectors.

Lastly, for the effect of innovation on productivity, our results show important differences across sectors confirming our third hypothesis. In this case the most important differences are within the AKP firms, in particular regarding the effect of innovation intensity on firms productivity. We can argue that it might take longer to capture the effects of innovation on firm's productivity for AKP, as innovation might be more complex in nature. We also observed that non-technological innovation plays an important role for firm's productivity, but in particular organizational innovation has a strong effect for PGS firms.

## **Policy implications and further research**

These results stress the importance for policymaking regarding the determinants of innovation and innovation intensity.

One of the important variables that impact the decision to innovate has to do with public funds for innovation. This result highlights that firms that access public funds to innovate have an active innovation strategy and show higher innovation intensity. Another variable refers to an open strategy to innovate, which suggests that firms with higher absorptive capacities are able to identify and benefit from external knowledge, and are also those firms that invest more in innovation activities. The challenge here for policy action is related to the need of addressing the internal failures in firms that keep them away from developing an active innovation strategy, this includes the establishment of networks with other agents to benefit from the knowledge outside the firm, identifying also different schemes to use scientific sources of information from universities and public research centres. Additionally, government programs need to recognize the importance of public sources of information (Internet, journals, patents, publications, fairs or meetings) to support innovation in particular for the services sector.

Interestingly, our results point out that foreign ownership has a negative effect on the decision to engage in innovation activities and innovation intensity for firms in AKP and MPG. On the other hand, once firms engage in innovation activities, foreign ownership plays an important role in the innovation output for MPG and PGS, which might indicate that once these firms decide to engage in innovation activities, foreign ownership plays an important effect in the development of innovations. Government programs need to provide insights or target how foreign owned firms, in particular for MPG, PGS and SIS, can increase their decision to engage in innovation activities and innovation intensity.

Some government programs like PROSOFT addresses the importance of non-technological innovation, mentioning that engagement in value chains can bring opportunities to generate organizational innovations. The program also recognizes the importance of market innovation, but the main challenge lies in supporting firms in different industries to grasp more on the benefits from market and organizational innovation to increase firms' productivity.

Another challenge that requires policy action is the need to understand the different innovative behavior between the different sectors and also understand the interaction among them. Identifying why MPG, and PGS followed by SIS firms are able to grasp more benefits from their investment on innovation than AKP firms.

This study also suggests some recommendations for advancing the sample design for future surveys of ESIDET in Mexico. ESIDET 2010 represented a significant advance in coverage, including firms with 20 employees or more, unlike previous versions that only included firms with 50 employees or more. However, a detailed analysis of the biases of ESIDET 2010 compared to the census data from 2009 would suggest including more firms with less than 250 employees in the sample design in order to have a greater coverage.

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