Innovation Determinants in the Spanish Service Sector
Another Type of Innovation? An Empirical Study

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Abstract

This paper estimates the determinant factors of innovation and R&D in Spain. The objective is to study if there are differences in innovation between services and manufacturing industries, as well as checking whether there are differences across level of technology/knowledge. In order to do this, an empirical–theoretical model based on the one developed by Crépon et al. (1998) is estimated using a panel data collected by the Technological Innovation Panel (PITEC); the model explains productivity through innovation output and innovation output in terms of R&D. Results show that although innovation intensity has a positive effect on output innovation for all subsectors except for Low-Tech Manufacturing Industries, the size of this effect is different.

Keywords: innovation, service sector, econometrics, Spain

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1 Introduction

The majority of academic studies on economic innovation continue to focus on manufacturing firms and industries. However, a number of arguments suggests that paying more attention to services is appropriate. For starters, approximately 75% of the GDP in industrialized economies corresponds to the service sector. It is the sector that generates the highest level of employment and gross value added. To give an example, in the case of Spain, in the year 2009 services generated two thirds of the GDP and more than 70% of employment. Furthermore, in the following decades it is expected that services, especially those that are knowledge-intensive, will be the driving force of industrialized economies.

Although the innovation in manufacturing industries typically implies technological and process innovations that result in an increase of labor productivity (and thus, reduce the level of employment in the sector), services are different in this respect, in the sense that the opportunity to reduce employees is smaller. Therefore, services are expected to stimulate employment in the following decades in industrialized economies; but at the same time, since most services are lagging in terms of labor productivity growth, there is a fear that this will slow down economic dynamism as the importance of service activities in the GDP of industrialized economies keeps increasing.

In this paper, we begin by comparing innovation data between industry and services to show that the determinant factors of innovation in industry and services are indeed different, and thus, service innovation studies require another approach. The data available does suggest that industry and services innovate differently. The ratio of turnover from products new to the firm is higher in the case of the manufacturing sector when compared to services, and manufacturing spends more on innovation than services. These differences must be accounted for, and that is why the study of services innovation must be approached from a different perspective than what has been used to study innovation in the manufacturing industry. Therefore, we use a version of the model developed by Crépon et al (1998), that explains productivity through innovation output and innovation output in terms of R&D. A set of four equations describes how firms decide whether to invest in R&D and its size; what knowledge is produced as a result of this investment, and how output is produced (the output production function) using this knowledge as an input as well as physical and labor factors. The first three equations of the model, together with an equation that modelizes exports, are estimated simultaneously to understand the driving factors behind innovation expenses and innovative sales.

In short, the question we are trying to answer is: does innovation in services differ from innovation in manufacturing? or does it differ across level of technology/knowledge? The existing literature presents several answers to this matter. Gallouj and Weinstein (1997) study the unique characteristics of services and briefly outline two complementary groups of studies on innovation in services: the first one focuses on the introduction of technical equipment in service firms, while the second one introduces the notion of non-technological forms of innovation. The latter one will be of special interest to us, since it states that frameworks which were originally developed for the industrial sector do not necessarily apply to service activities.

However, others (Tether, 2005) point out that, although services do indeed innovate (Tether et al., 2001; Gallouj, 2002; Miles, 2005), the answer to whether this innovation is different from the manufacturing industry is not all that clear. Even though evidence suggests that services tend to have a different orientation in innovation when compared to manufacturers (an organizational change, for instance, is popular among services but uncommon amongst manufacturers), according to Tether (2005) "there is no distinctively different or unique service pattern of innovation". In general, it appears that there are bigger differences within each sector (knowledge-intensive services vs. the rest of services, and high-tech industries vs. other industries) than between the two sectors.

Leiponen (2008) recognizes that, although R&D activities are very important for service innovation, (at least in the service industries covered by the Finnish sample they use), the Community Innovation Surveys (CIS) questionnaires were in fact developed with manufacturing innovation in mind and might miss some important elements of service innovation. This, we believe, is important; the main problem with service innovation data might be that services innovate in ways that are not easily computed or calculated. Evangelista (2000) studies the characteristics of innovation in the Italian service sector using 1993-1995 survey data. One of the most important conclusions is that R&D activities (measured through expenses) are not an important source of innovation save for a small number of firms, which focus on science and technology. This seems to agree with our idea that the service sector innovation is different from manufacturing industry innovation because it focuses in non-R&D innovation.

Crépon et al. (1998) study "the links between productivity, innovation and research at the firm level", by proposing a new approach to the problem of studying the impact of research and innovation on productivity. Their approach is to construct an econometric model that explains productivity through innovation output and innovation output in terms of R&D, with a set of equations that form a recursive non-linear system. Their findings, which are consistent with studies using more widespread methods, indicate that innovation output increases with its research effort; and that firm productivity is positively correlated with a higher innovation output. Segarra-Blasco (2010) uses a version of the model developed by Crépon et al. (1998) to analyze the determinants of R&D and the effect of innovation in labor productivity in firms from Catalonia. This paper is of special interest to us because it focuses on knowledge-intensive services (KIS) and their strategic role in promoting innovation.

In the following pages, we begin by studying the differences in innovation between the service sector and the manufacturing industry sector. We continue with the proposal of a model that analyzes these differences by studying the relationship between R&D expenditure, innovation and productivity. Then we describe the data we use for our analysis and state the econometric strategy that is followed to estimate the model. We finish the paper by discussing the results obtained so far and suggesting possible extensions.

2 Motivation

In this section we study the differences in innovation[1] and R&D across services and industries. Like it was previously mentioned, studies on innovation have primarily focused on the industry sector. However, given the relative weight of the service sector in first world economies, it is important to understand the innovation mechanism of such sector as well. Therefore, we will compare innovation data between manufacturing industry and services to show that the determinant factors of innovation in manufacturing industry and services are indeed different, and thus, service innovation studies require another approach.

In order to carry out this comparison, we use information available from the following sources: the Innovation Union Scoreboard (IUS) (which has replaced the late European Innovation Scoreboard (EIS)), Eurostat, the Community Innovation Surveys (CIS) and the OECD. The IUS is appropriate because it provides a general assessment of the innovation performance of the EU-27 Member States (although we focus on Spain) and the relative strengths and weaknesses of their research and innovation systems. It does not, however, allow us to differentiate among service and industry innovation. This is done using the CIS, which provides insightful information on the composition of the expenses made on innovation and R&D.

Therefore, the IUS is simply an interesting measure to check how Spain compares to the rest of the European countries. According to the 2010 IUS, Spain is a moderate innovator, behind innovation leaders and followers (countries such as Denmark, Finland, Germany, Austria, Belgium, Cyprus, Estonia, France, Ireland, Luxembourg, Netherlands, Slovenia and the UK). Spain shows a performance below the average EU-27. Relative weaknesses are in Firm Investments, Linkages & Entrepreneurship, Intellectual Assets and Innovators. Relative strengths are in the indicator on International Scientific Publications and in the dimensions Finance & Support and Outputs (except on License & Patent Revenues from Abroad). Figure 1 shows the Summary Innovation Index of 2010, computed by the European Innovation Scoreboard based on 24 different indicators of innovation[2]. In this figure we can clearly see how Spain (ES) falls behind more advanced European countries, like Germany, Finland, Denmark and Sweden.

Another innovation indicator, which shows that the innovation in services and in manufacturing is different, is the ratio of turnover from products new to the firm, it is defined as the ratio of turnover from products new to the enterprise as a % of total turnover. It is based on the CIS and covers at least all enterprises with 10 or more employees (smaller firms are not included). Note that an innovation has been defined as a new or significantly

[1] We define innovation as a new or significantly improved product (both good or service) introduced to the market or the introduction within an enterprise of a new or significantly improved process.

[2] These indicators include measures such as the Number of Doctorate Graduates, the Expenses in R&D, or the Number of Firms Introducing New Products; and can be checked in the official Innovation Union's performance scoreboard for Research and Innovation Report.

Figure 1: EU Member States' Innovation Performance (2010)

Source: Innovation Union Scoreboard, Pro Inno Europe.

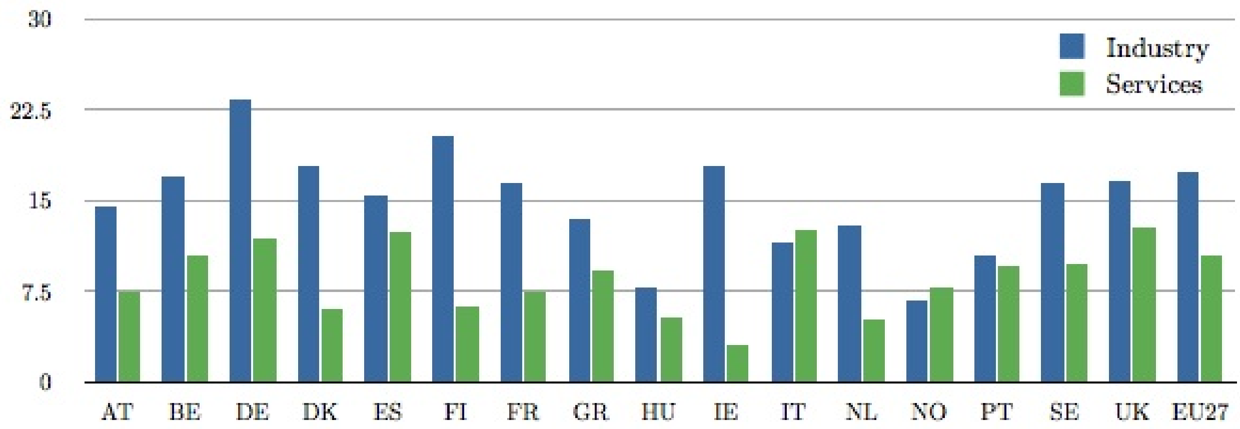
improved product (both good or service) introduced to the market or the introduction within an enterprise of a new or significantly improved process. Since this measure is used as a dependent variable latter on in our model, it is of special interest to us.

Figure 2 summarizes the results obtained for different countries of the EU–27, differentiating between industry and services, in the year 2004. Except for Italy and Norway, all other countries show consistently larger ratios in industry than in services, which might initially suggest that the industry sector innovates more. However, as we continue with our analysis we will see that the industry doesnt necessarily innovate *more*, but that it innovates primarily on *products* (which is what Figure 2 is measuring), while the service sector innovates on organization and commercialization (both of which are harder to compute into statistics).

Statistics on patents are also interesting measures of how the industry and services innovate differently. However, since patents are classified by technology field and not by sectors, there is no direct correspondence between the two[3]; so we use several technologies only as an *example* of innovation in the industry and service sectors: biotechnology and nanotechnology as the leaders in industry innovation, and Information and Communications Technology (ICT) patents also as the cutting edge technology in the service sector innovation. Since the objective is to measure inventiveness, the data selected takes as ref-

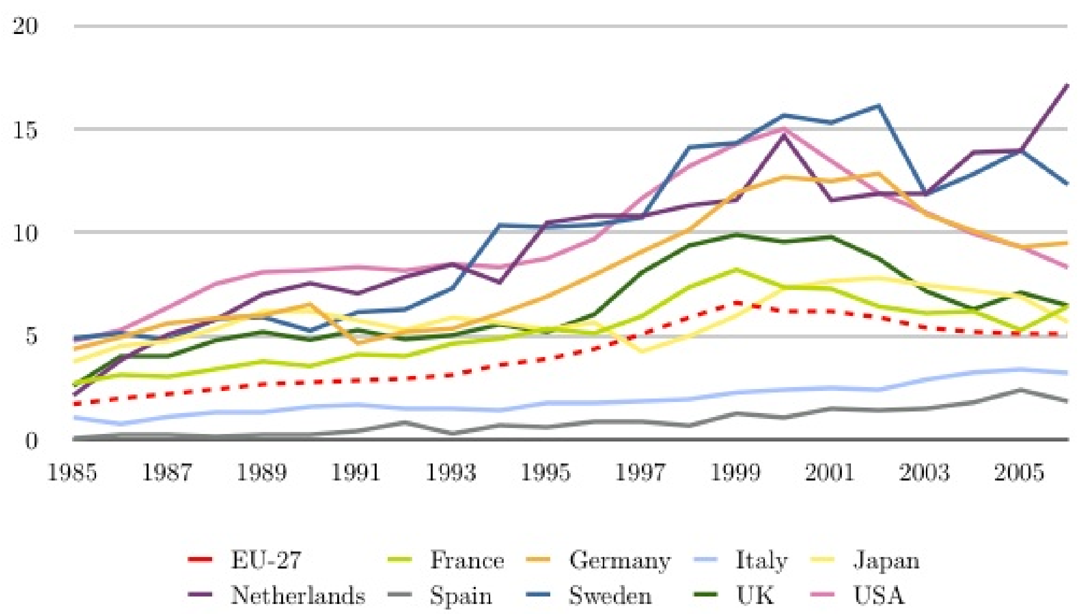
[3]Patents are classified by IPC code while sectors are classified by NACE code.

Figure 2: Ratio of turnover from products new to the firm by sector (2004)



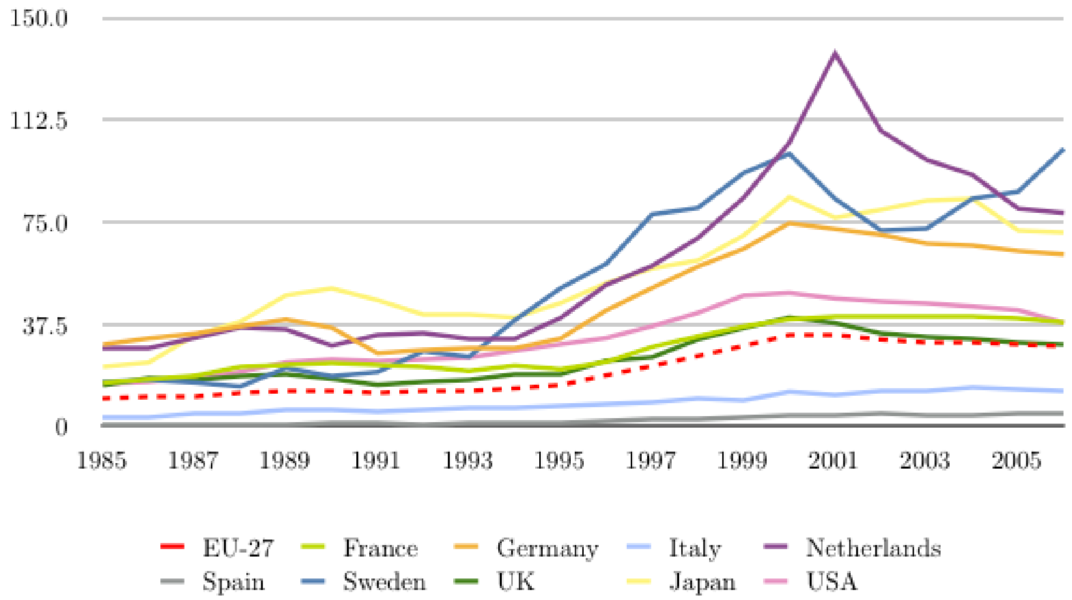
Source: Community Innovation Survey, Eurostat.

Figure 3: Evolution of the number of patent applications to the EPO in the fields of biotechnology and nanotechnology, per million of habitants



Source: Community Innovation Survey, Eurostat.

Figure 4: Evolution of the number of patent applications to the EPO in the field of ICT, per million of habitants



Source: Community Innovation Survey, Eurostat.

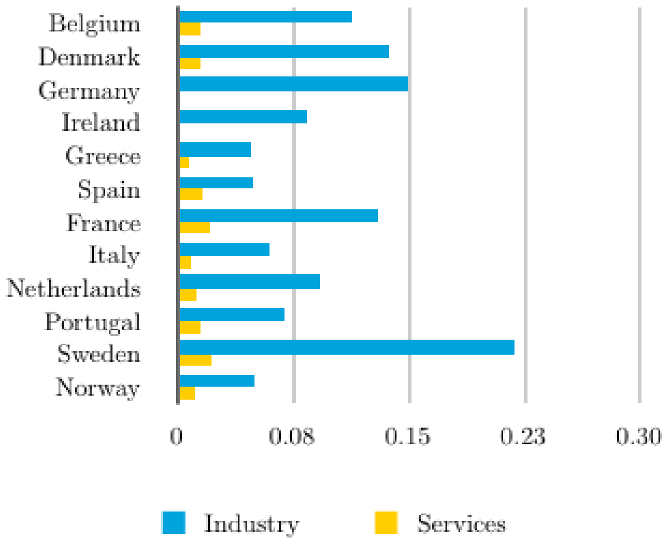
erence the priority date (the one closest to the date of invention), the inventor's country of residence and the patent applications made to the European Patent Office (EPO)[4].

Figures 3–4 depict the evolution in the number of patents per million of habitants. They both show a steady increase in the number of patent applications since 1985, although countries like Sweden, Netherlands and Germany are clearly leaders in both accounts (bio- and nanotechnology as well as ICT); USA is also leader in bio- and nanotechnology, and Japan is leader in ICT. Spain clearly falls behind the average of the EU–27 countries.

It should also be noted that the number of patent applications per million habitants is far greater, on average, for the field of ICT compared to the other two fields. Although this might initially suggest that the cutting edge field in services innovates more than the industry counterparts, we have to be careful with this assumption: it might be that a only a small percentage of ICT patents correspond to the service sector. In fact, if we take into account the report on patents in the service industries by the Fraunhofer institute (2003) which suggests that approximately 3% of the ICT application patents correspond to the

[4]We use patent applications and not grants because of the time lapse between an application and a grant. However, data on the Triadic Patent Families was also available; and although statistics based on this family improve international comparability and the inventions are in general of higher value, after careful consideration we decided against using it due to the non-publication of applications by the USPTO until 2001.

Figure 5: Intensity of total innovation expenses, by sector (2008)



Note: Exceptions to the reference year 2006 (Greece, Portugal); 2004 (Denmark, Germany).
Source: Community Innovation Survey, Eurostat.

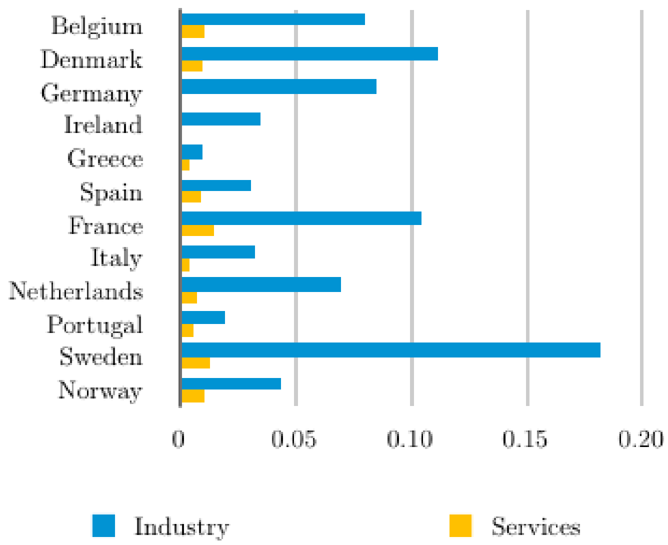
service sector, the numbers between the two figures are much more comparable, and show that the number of patent applications among the leading manufacturing fields and the leading service sectors are quite similar. This evidence suggests that the differences in innovation are much more pronounced between low tech manufacturing industries and non–knowledge intensive services, than between high tech manufacturing industries and knowledge intensive services.

If we take look at the intensity of expenses in innovation[5] in Tables 1–2 and Figures 5–7 we can conclude that the intensity of expenses in the industry sector is quite bigger compared to the service sector, especially in R&D expenses. This gap, although still very large, is reduced a little in the case of non–R&D innovation expenses (Figure 7).

One would expect that industry and services innovate differently – industry might spend more on R&D innovation, on products and processes; while services might spend their time and effort improving the way to commercialize or market their service. Unfortunately, this type of expense is not easily computed into statistics, which might explain the large gap between expenditure in industry and in services. Table 1 captures this somewhat. Taking into account that R&D expenses serve as a measure of technological innovation, while non R&D expenses measure other type of (non-technological) innovation, our initial expectation would then be that the percentage of non R&D expenses is higher in the case

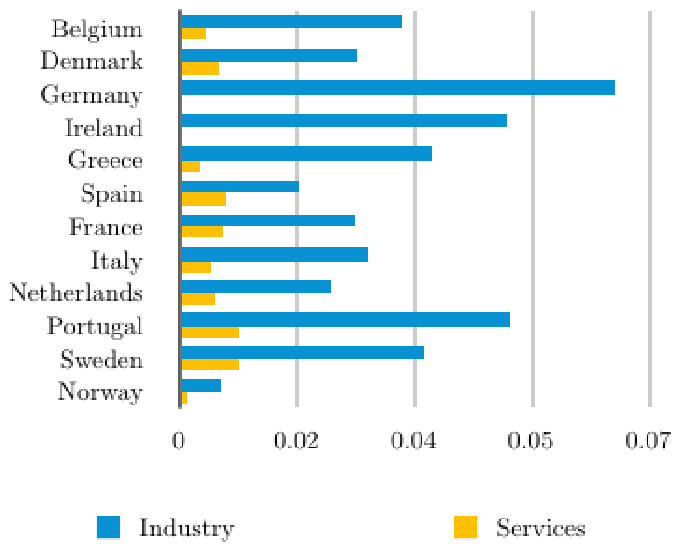
[5]The data is compiled from Eurostat and based on the Community Innovation Survey. The absolute value of the expenses are relativized by dividing them by the corresponding GDP to obtain the intensity of the innovation expenses.

Figure 6: Intensity of R&D expenses, by sector (2008)



Note: Exceptions to the reference year 2006 (Greece, Portugal); 2004 (Denmark, Germany).
Source: Community Innovation Survey, Eurostat.

Figure 7: Intensity of non-R&D innovation expenses, by sector (2008)



Note: Exceptions to the reference year 2006 (Greece, Portugal); 2004 (Denmark, Germany).
Source: Community Innovation Survey, Eurostat.

Table 1: Percentage of R&D and non-R&D expenses from total innovation expenses, by sector (2008)

	Manufacturing		**Services**	
	R&D	**Non R&D**	**R&D**	**Non R&D**
Belgium	70.96%	29.04%	74.59%	25.41%
Denmark	80.88%	19.12%	62.73%	37.27%
Germany	56.71%	43.29%		
Ireland	41.69%	58.31%		
Greece	20.92%	79.08%	55.47%	44.53%
Spain	63.51%	36.49%	55.94%	44.06%
France	79.92%	20.08%	69.75%	30.25%
Italy	53.39%	46.61%	45.46%	54.54%
Netherlands	75.49%	24.51%	58.22%	41.78%
Portugal	28.50%	71.50%	40.43%	59.57%
Sweden	83.34%	16.66%	60.15%	39.85%
Norway	87.91%	12.09%	90.92%	9.08%

Note: Exceptions to the reference year 2006 (Greece, Portugal); 2004 (Denmark, Germany).
Source: Community Innovation Survey, Eurostat.

of services. This is, in fact, what we see in Table 1 for the majority of the countries, except for Greece and Portugal.

One thing is clear from the analysis conducted in this chapter: industry and services innovate somewhat differently. The ratio of turnover from products new to the firm is higher in the case of the industrial sector, and the industry spends more on innovation than services. Table 2 also shows the wide gap in the intensity of innovation expenses, although this gap is narrower in the case of intensity of non R&D innovation expenses. Therefore, these differences must be accounted for, and that is why the study of services innovation must be approached from a different perspective. In the following chapter, we will introduce a version of the model developed by Crépon et al (1998).

Table 2: Intensity of expenses in total innovation and R&D, by sector (2008)

	Intensity of total innovation expenses	**Intensity of total innovation expenses**		**Intensity of R&D expenses**		**Intensity of non R&D innovation expenses**	
		Manufacturing	**Services**	**Manufacturing**	**Services**	**Manufacturing**	**Services**
Belgium	2.70%	11.34%	1.45%	8.05%	1.08%	3.29%	0.37%
Denmark	3.03%	13.77%	1.52%	11.14%	0.95%	2.63%	0.57%
Germany		14.98%		8.49%		6.48%	
Ireland		8.37%		3.49%		4.88%	
Greece	0.95%	4.76%	0.69%	0.99%	0.38%	3.76%	0.31%
Spain	1.63%	4.84%	1.59%	3.07%	0.89%	1.77%	0.70%
France	2.92%	13.02%	2.12%	10.40%	1.48%	2.61%	0.64%
Italy	1.62%	6.00%	0.87%	3.20%	0.39%	2.80%	0.47%
Netherlands	1.99%	9.20%	1.21%	6.94%	0.71%	2.25%	0.51%
Portugal	2.04%	6.90%	1.48%	1.97%	0.60%	4.93%	0.88%
Sweden	5.10%	21.82%	2.21%	18.18%	1.33%	3.64%	0.88%
Norway	0.94%	4.99%	1.15%	4.38%	1.05%	0.60%	0.10%

Note: Exceptions to the reference year 2006 (Greece, Portugal); 2004 (Denmark, Germany).
Source: Community Innovation Survey, Eurostat.

3 Theoretical–Empirical Framework

In this section we present a structural model that relates R&D expenditure, innovation and productivity. It is based on a version of the theoretical model studied by Crépon et al. (1998) and on the empirical model presented by Segarra–Blasco (2008). The model by Crépon et al. (CDM model for short) explains productivity through innovation output and innovation output in terms of R&D. A set of four equations describe how firms decide (a) whether to invest in R&D and (b) its size, (c) what knowledge is produced as a result of this investment (the determinants of the R&D investment are analyzed), and (d) how output is produced (the output production function) using this knowledge as an input as well as physical and labor factors. Since estimating the output production function was not possible due to the data available, our model takes the first three equations of the CDM model and adds a fourth one to estimate the endogenous variable exports as a percentage of total sales.

The first equation therefore describes the R&D decision; whether a firm is engaged in R&D activities or not[6]. We assume that there is a latent dependent variable RD_i for each firm i described by a generalized Tobit model,

$$RD_i = \beta_1 X_{1i} + u_{1i}, \tag{1}$$

where RD_i expresses a decision criterion (such as the expected present value of the firms profit resulting from the investment in R&D; Crépon et al., 1998); β_1 is the vector of parameters to be estimated, X_{1i} is a vector of determinants of the R&D decision, and u_{1i} is a randomly distributed error term. The propensity to engage in R&D activities is an unobserved latent variable. Therefore,

$$RD_i = \begin{cases} 1 & \text{if } RD_i^* > 0 \\ 0 & \text{if } RD_i^* \leq 0. \end{cases}$$

where RD_i is a binary variable, that is zero for non–R&D firms and one for R&D firms.

We then describe the size or intensity of the R&D investment. A latent intensity of research RS_i of firm i is determined by a second equation

$$RS_i = \beta_2 X_{2i} + u_{2i}, \tag{2}$$

where X_{2i} is the vector of explanatory variables, β_2 is the coefficient vector to be estimated, and u_{2i} is a random error term. Notice that the set of explanatory variables in the two equations are not necessarily the same. Since RS_i is only observable when RD_i is equal to one, we also have to specify the joint distribution of the error terms in order to have a model that can be estimated. Therefore, we will assume that the disturbances are jointly normally distributed, that is,

$$\begin{pmatrix} u_{1i} \\ u_{2i} \end{pmatrix} \overset{iid}{\sim} N\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_1^2 & \rho\sigma_1\sigma_2 \\ \rho\sigma_1\sigma_2 & \sigma_2^2 \end{pmatrix} \right),$$

[6] In the following section we see that the sample available for firms with fewer than 200 employees is conditional on them having either extramural or intramural R&D investment.

where σ_1 and σ_2 are the standard errors of u_{1i} and u_{2i} respectively, and ρ is their correlation coefficient. This equation can be modeled using either a Heckman selection model (to account for the selection into having a positive innovation or R&D expenses) or a generalized Tobit model (to account for the variable being truncated at zero, since a large number of firms do not have positive innovation or R&D expenses).

The third equation in the model is an output innovation function, which depends on R&D and has the following general form

$$OI_i = \gamma RS_i + \delta X_{3i} + u_{3i}, \tag{3}$$

where OI_i is the output innovation of firm i, RS_i is the size or intensity of R&D of firm i, measured as the amount of R&D expenditure per employee, X_{3i} is the vector of explanatory variables of the knowledge production, γ and δ are the vector of coefficients to be estimated, and u_{3i} is a random error term. Notice that RS_i is an endogenous variable in equation (3), so we estimate all equations simultaneously to avoid problems with the error term.

Since the variable exports, which is included in the set of explanatory variables in the previous equations, is considered to be endogenous, we also estimate the following equation,

$$E_i = \alpha X_{4i} + u_{4i}, \tag{4}$$

where E_i is the variable exports as a percentage of total sales of firm i, α are the vector coefficients to be estimated, X_{4i} is a vector of firm characteristics, and u_{ui} is a random error term.

The last relationship is the productivity equation. Although, like we mentioned, this one is not estimated due to lack of data, it is important to also explain this one in order to understand the full model. This equation explains the determinant factors of the level of productivity using an augmented Cobb–Douglas production function, with physical capital and employment as usual, plus a vector with different knowledge proxies (such as R&D expenditure and innovation output), and a vector of the firm's characteristics. Assuming constant returns to scale and taking logarithms, the output production function has the following form:

$$y_i = \pi_1 l_i + \pi_2 k_i + \pi_3 OI_i + \pi_4 X_{5i} + u_{5i}, \tag{5}$$

where l_i is the labor factor, k_i is the physical capital factor, OI_i is a vector of output innovation, X_{5i} is a vector of firm characteristics, and u_{5i} is a random error term. π_1-π_4 are the vector coefficients to be estimated. Since the variables are in logarithms, π_1, π_2, π_3 and π_4 measure the elasticity of total factor productivity with respect to labor, physical capital, output innovation and the firms characteristics, respectively.

Taken together, equations (1)–(5) form a recursive nonlinear system. In section 5 we deal with the estimation of equations (1)–(4), which explain the factors behind the innovation decision, its size, and its effect on innovative sales.

4 Description of the Data

The data we use to conduct the analysis described in the previous chapter is the Technological Innovation Panel (PITEC). PITEC is a statistical instrument that follows the technological innovation activities conducted by Spanish firms. The database is built by the National Statistics Institute (INE) in collaboration with the Spanish Foundation for Science and Technology (FECYT), the Cotec Foundation for the Technological Innovation, and a group of university researchers. The data, which is derived from the Community Innovation Survey (CIS) and follows the guidelines established in the Oslo Manual, is a panel data that follows, between the years 2003-2008, the activities in technological innovation carried out by Spanish firms. This will allow us to compute more precise estimations of, for example, the importance of the innovation activities, the evolution of their composition and of the expenses in innovation. It will also enable us to appreciate the heterogeneity of the decisions adopted by firms and their effects; for instance, the composition of the total expenses in intramural and extramural R&D, as well as the effect on productivity.

The database is publicly available in the following webpage: `http://icono.fecyt.es/contenido.asp?dir=05)Publi/AA)panel`. The data is anonymized to avoid the possibility of firms being identified. This anonymization process implies the following modifications[7]:

1. Replacement of firm–level observations of five quantitative variables (turnover, investment, number of employees, innovation expenditures, and number of R&D employees) with data generated to hide the original observations;
2. Replacement of firm-level observations of the rest of the quantitative variables with the percentage with respect to the aggregate value (for example, intramural R&D is replaced with the percentage that the intramural R&D represent from total innovation expenditure);
3. Replacement of the four–digit NACE codes with a 56 industry breakdown until 2008 and with a 44 industry breakdown from 2008 (both breakdowns are available for 2008); and
4. Censoring of the data of a given number of firms (45, 63, 81, 90, 92 and 93 firms in 2003, 2004, 2005, 2006, 2007 and 2008, respectively).

Given the anonymization method applied, the expected estimation bias is small.

The database is initially (in 2003) divided in two samples: a sample of firms with 200 or more employees, (sample of big firms, MEG), which represented 73% of all firms with 200

[7]Detailed description of the anonymization method can be found in `http://icono.fecyt.es/05)Publi/AA)panel/bdPITEC_June2010_ing.pdf`, in the appendix.

Table 3: Distribution of firms across samples, by year

	2003		2004		2005		2006		2007		2008	
	Freq.	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**
Large Firms	3459	47.94	3505	34.73	3413	28.21	3391	28.18	2764	47.05	3175	28.40
Small Firms	3768	52.06	6587	65.27	8595	71.79	8643	71.82	3111	52.95	8006	71.60
Firms w R&D	4793	66.23	6278	62	8429	70.42	8439	70.13	3943	67.11	7837	70.09
Total	7237		10092		12098		12034		5875		11181	

Source: Personal compilation based on PITEC data.

or more employees; and a sample of small (fewer than 200 employees) firms with intramural R&D expenditures (MID). Furthermore, in 2004, a sample of small firms with external R&D expenditure and no intramural R&D expenditure (MIDE); and a representative sample of small firms with no innovation expenditure (MEP) were included. However, the given the size of the MEP sample, it is not representative of small firms; and the analysis conducted on small firms will be conditional on them having either intramural or extramural R&D expenditure. This is the reason why the estimation of equations (1)–(3) is done for big firms only.

The following table presents the distribution of the samples mentioned above. Although it might seem at a first glance like we have a representative sample of small firms, in reality, the vast majority (over 80% across all years) of the observations of small firms come from small firms with positive R&D. Obviously, this is not a representative sample of small firms. We do have, however, a representative sample of large firms, as well as a representative sample of firms with positive R&D expenses (comprised of both large and small firms).

Since we analyze the determinants of innovation in services vs. the manufacturing industry sector (and also, the determinants of innovation in the cutting edge fields of each of those sectors, i.e., Knowledge Intensive Services and High-Tech Industries respectively) it is also interesting to study the distribution of firms into each of those subsectors. The following table analyzes the evolution of the distribution of firms into each of these four groups: high-tech industries (HT), low-tech manufacturing industries (LT), knowledge intensive services (KIS), and other services (NKIS)[8]. Table 4 suggests that the distribution of firms into subsectors is quite homogeneous across the years. Also notice that manufacturing industry and services do not add up to 100 because agriculture and non manufacturing industry have not been included in the analysis.

[8]A detailed table, based on the OECD and Eurostat, of the classification of manufacturing and services is included in Appendix A.3.

Table 4: Distribution of firms into subsectors, by year, in percentage of the total

	2003	2004	2005	2006	2007	2008
Manufacturing	**50.87**	**52.26**	**52.02**	**51.94**	**53.64**	**51.52**
HT	24.99	23.76	23.05	22.86	26.30	22.37
LT	25.88	28.50	28.97	29.08	27.34	29.15
Services	**34.47**	**34.47**	**33.77**	**33.75**	**30.74**	**33.99**
KIS	21.96	21.96	22.71	22.94	18.96	22.86
NKIS	12.51	12.51	11.06	10.81	11.78	11.13

Source: Personal compilation based on PITEC data.

We now turn our attention to the descriptive statistics of some indicators of R&D and innovative activities[9], paying special attention to the differences between the four categories (HT, LT, KIS, NKIS). Although Table 5 is a summary of the descriptive statistics across the time variable, we have also obtained the statistics for each year to conclude that there are no big differences across years. Notice that for dummy variables, the mean represents the distribution of the variable. Table 5 is computed using the whole database (both big and small firm), while in Tables 6–7 we will focus only on the data we will be using for our analysis (big firms) and therefore we present a more exhaustive analysis of the main descriptive statistics, number of observations, etc.

The first difference we notice is the gap in average size, both in sales and in the number of workers: the average for NKIS is huge (146 millions of euros and 802 workers on average) compared to the other subsectors. This is probably because wholesale and retail are included in this group, which employ a large number of people and have high turnover (even if the value added is low). That is why it is important to control for size when conducting the analysis in the following section. It is also interesting to notice that the subsector that has newer firms on average is KIS.

Another notable statistic is the average percentage of exports out of total sales: services as a whole but specially KIS (4.95%) fall behind HT (24.66%) and LT (18.91%) manufacturing industries. This is an initial indicator that services will innovate less or differently than manufacturing; if they do not export as much they do not compete in bigger markets and thus their need to innovate is smaller. This is related to the statistics regarding the market of the firm: the majority of manufacturing industries declare that they operate in foreign countries, while services do not.

Another important point is the differences across technological, non-technological and other type (organizational, commercialization) of innovations: the gap is extremely wide in product and good (technological) innovations, but a lot narrower (in some cases almost

[9]The definition of the variables used is included in Appendix A.2.

non-existent) in processes and non-technological innovations. These statistics seem to agree with the observation that manufacturing industries might innovate in products, while services innovate in non-technological innovation (the latter, of course, being harder to measure).

Also worth noting is the fact that the average number of firms who declare to have introduced a product new to the firm or new to the market is quite homogeneous across subsectors (approximately around 75% and 55% respectively), but this is not the case when we check the average percentage of sales that correspond to products new to the firm or the market: the statistic is a lot smaller for NKIS (7.01%, 3.67%), although KIS (13.95%, 11.04%) seem to pull their weight in this regard, surpassing even HT (16.87%, 10.72%) manufacturing industries.

With respect to the average expenses in innovation as a percentage of total sales, HT (2.90%) and KIS(1.96%) have comparable figures even if HT is still larger, while LT is lower (0.80%) and NKIS even smaller (0.24%). There are also wide differences across the number of patent applications.

Table 5: Descriptive statistics of variables by subsector

	Manufacturing		**Services**	
	HL	**LT**	**KIS**	**NKIS**
Type of firm				
Public	0.37%	0.50%	4.60%	3.31%
Private (national)	82.07%	88.00%	83.47%	80.59%
Private (multinational)	17.48%	11.44%	7.47%	16.02%
Research association	17.48%	11.44%	7.47%	16.02%
Belongs to a group	40.49%	36.90%	36.88%	48.40%
Is a new (< 2 years) firm	1.38%	1.07%	4.10%	0.76%
Average size (sales, millions of euros)	59.00	60.50	82.90	146.00
Average percentage of exports, out of sales	24.66%	18.91%	4.95%	10.29%
Average size (no, of workers)	183.25	179.44	344.74	802.22
Average percentage of female workers	24.13%	27.25%	38.71%	42.41%
Market of the firm				
Local/province	93.36%	95.21%	94.13%	93.24%
National	95.64%	92.93%	81.79%	80.68%
Other European countries	78.77%	72.98%	31.56%	47.47%
Rest of the countries	68.61%	57.42%	20.90%	29.34%
Have innovated (technological innovations)				
On products	71.26%	54.22%	53.40%	25.15%
On goods	67.46%	50.07%	33.81%	19.88%
On services	22.04%	17.50%	40.67%	13.95%
On processes	58.30%	59.97%	48.32%	33.05%
Have made non-technological innovations				

Table 5: (continued)

	Manufacturing		Services	
	HT	**LT**	**KIS**	**NKIS**
On strategies	31.91%	28.13%	38.88%	20.11%
On management and administration	40.30%	36.77%	39.26%	25.41%
On organization	41.97%	38.75%	42.03%	26.74%
On marketing	29.02%	27.70%	31.06%	21.88%
On aesthetic/subjective things	42.58%	39.24%	32.64%	21.99%
Have made organizational innovations				
On management systems	38.87%	36.20%	43.80%	30.91%
On the work organization	37.19%	34.59%	39.59%	27.56%
On the relationships with other firms/entities	16.35%	11.27%	25.01%	11.92%
Have made innovations on commercialization				
On the design or packaging of a product	21.34%	21.22%	13.65%	12.59%
On the method of sales or distribution	12.76%	12.19%	16.22%	13.23%
Have introduced products new to the firm	77.03%	77.29%	71.63%	74.00%
Average percentage of products new to the firm, out of sales	16.87%	13.57%	13.95%	7.01%
Have introduced products new to the market	58.24%	54.40%	60.13%	52.43%
Average percentage of products new to the market, out of sales	10.72%	7.21%	11.04%	3.67%
Have applied for patents	20.57%	12.31%	10.66%	4.51%
Average no. of patent applications per firm	0.9748	0.4841	0.4619	0.1502
Have intramural R&D expenses	78.10%	59.19%	62.63%	25.06%
Average percentage of intramural R&D expenses, out of total innovation expenses	62.96%	44.97%	51.81%	18.82%
Have extramural R&D expenses	37.30%	29.00%	26.87%	12.78%
Average percentage of extramural R&D expenses, out of total innovation expenses	9.67%	9.10%	7.17%	5.11%
Average percentage of introduction of innovation expenses, out of total innovation expenses	3.66%	3.47%	2.75%	1.89%
Total expenses in innovation (millions of euros)	1.71	0.48	1.62	0.35
As a percentage of total sales	2.90%	0.80%	1.96%	0.24%

Source: Personal compilation based on PITEC data.

Having described the main characteristics of the whole dataset available from PITEC, from now on we focus on a subsample of the data; the subsample that we use to estimate the model presented in section 3. This subsample is selected on the basis that the analysis is conducted for big firms: both firms that innovate and firms that do not innovate are included; while in the case of small firms, we do not have a representative sample, so the analysis would have to be conditional on having positive innovation activities.

Furthermore, the dummy variables "market of the firm" (local, national, EU, other foreign countries) were not available for the year 2003 so this year is not included in the analysis, since these variables seem important to explain the probability of a firm innovating (and if we check the significance of these variables after conducting the analysis, they are in fact significant). It was decided not to include local market as a dummy variable due to the fact that almost 100% of the firms operate in the local market. The sample has also been restricted to HT, LT, KIS and NKIS firms, so that agriculture and non manufacturing firms are not included in the sample.

Tables 6 and 7 are a summary of the descriptive statistics of the main dependent variables (RD, RS and IO, measured in different ways) and explanatory variables (number of workers, % of female workers out of total workers, type of firm, firm belongs to a group, firm is less than two years old, % of exports out of sales, market of the firm, and if a firm cooperates with other firms to innovate). Main descriptive statistics such as the mean and standard deviation are included, as well as maximum, minimum and several percentiles (10%, 50% or median, and 90%), in order to obtain a clear picture of the distribution of the variables we use for the estimation of equations (1)–(3). At a first glance, we can see that we have enough observations to conduct our analysis, even if we further divide this into years.

If we take a look at the probability of engaging in R&D activities (RD R&D) or at the probability of engaging in innovation activities (RD innov), we see that there are huge differences in the average across subsectors: the highest probability is for HT manufacturing industries (0.78), while the lowest corresponds to NKIS (0.13). This difference is not nearly as big in the averages of innovation intensity, which suggests that although a larger number of manufacturing firms innovate, once they have decided to innovate, the funds they devote to innovating relative to their size is similar.

Other than that, we observe similar things than in Table 5, which suggests that smaller firms do not behave in a different way: the average size of the firm is smaller for manufacturing industries than for services (probably because NKIS includes retail), as is the percentage of female workers. The distribution into types of firms is quite similar, but the probability of belonging to a group of firms is higher on average in the case of manufacturing. There is also a big difference in the percentage of total sales that correspond to exports: while HT manufacturing firms export on average 25% of their sales, KIS only export on average on tenth of that. Even NKIS export more (7%). This difference is also visible in the market of the firms; services focus more on the national market, whereas manufacturing has a large international market. And again, there is a discrepancy in the variable OI: if we measure output innovation as a yes/no variable the average is similar across subsectors, but when reporting it as a percentage of sales from products new to the firm or new to the market, services clearly lag behind. This suggests that even though they have output innovation the innovation does not bring in a huge increase in sales.

Table 6: Descriptive statistics of dependent and explanatory variables, for manufacturing industries

	High Tech								Low Tech							
	N	**Mean**	**Std. Dev.**	**Min**	**Max**	**10%**	**50%**	**90%**	**N**	**Mean**	**Std. Dev.**	**Min**	**Max**	**10%**	**50%**	**90%**
RD (R&D)	2384	0.78	0.41	0	1	0	1	1	3617	0.57	0.50	0	1	0	1	1
RD (innov)	2384	0.83	0.38	0	1	0	1	1	3617	0.65	0.48	0	1	0	1	1
RS (R&D)	2384	0.02	0.03	0	0.24	0	0.01	0.05	3617	0.01	0.01	0	0.12	0	0.001	0.02
RS (innov)	2384	0.03	0.04	0	0.24	0	0.01	0.07	3617	0.01	0.02	0	0.12	0	0.002	0.03
OI (% new to firm)	2384	14.09	24.34	0	100	0	2.00	50.00	3617	10.11	23.59	0	100	0	0.00	30.00
OI (% new to market)	2384	9.52	20.09	0	100	0	0.00	30.00	3617	5.80	16.99	0	100	0	0.00	15.00
OI (new to firm y/n)	1709	0.80	0.40	0	1	0	1	1	1876	0.78	0.42	0	1	0	1	1
OI (new to market y/n)	1709	0.63	0.48	0	1	0	1	1	1877	0.60	0.49	0	1	0	1	1
OI (process innov y/n)	2384	0.68	0.46	0	1	0	1	1	3617	0.62	0.49	0	1	0	1	1
OI (product innov y/n)	2384	0.71	0.45	0	1	0	1	1	3617	0.51	0.50	0	1	0	1	1
OI (service innov y/n)	2384	0.24	0.43	0	1	0	0	1	3617	0.19	0.40	0	1	0	0	1
No. of workers	2384	662.47	1173.11	1	10434	203	360	1180	3617	517.71	585.50	5	4634	197	338	943
Female workers	2384	25.48	19.51	0	90	5	20	54	3617	27.59	23.54	0	100	4	20	65
Type of firm																
Public	2377	0.01	0.10	0	1	0	0	0	3606	0.01	0.09	0	1	0	0	0
Private	2377	0.99	0.10	0	1	1	1	1	3606	0.99	0.09	0	1	1	1	1
Research association	2377	0.00	0.00	0	1	0	0	0	3606	0.00	0.02	0	1	0	0	0
Belongs to a group	2384	0.87	0.33	0	1	0	1	1	3617	0.73	0.45	0	1	0	1	1
New firm	2384	0.00	0.05	0	1	0	0	0	3617	0.00	0.04	0	1	0	0	0
Exports	2384	25.04	28.41	0	100	0	12	73	3617	16.61	23.55	0	100	0	5	56
Market of firm																
National	2384	0.97	0.17	0	1	1	1.0	1.0	3617	0.95	0.21	0	1	1	1	1
EU	2384	0.89	0.31	0	1	0	1	1	3617	0.83	0.37	0	1	0	1	1
Other countries	2384	0.82	0.39	0	1	0	1	1	3617	0.71	0.45	0	1	0	1	1
Cooperates	2112	0.52	0.50	0	1	0	1	1	2721	0.39	0.49	0	1	0	0	1

Source: Personal compilation based on PITEC data.

Table 7: Descriptive statistics of dependent and explanatory variables, for services

	Knowledge Intensive Services								Non Knowledge Intensive Services							
	N	**Mean**	**Std. Dev.**	**Min**	**Max**	**10%**	**50%**	**90%**	**N**	**Mean**	**Std. Dev.**	**Min**	**Max**	**10%**	**50%**	**90%**
RD (R&D)	3043	0.37	0.48	0	1	0	0	1	3315	0.13	0.34	0	1	0	0	1
RD (Innov)	3043	0.51	0.50	0	1	0	1	1	3315	0.20	0.40	0	1	0	0	1
RS (R&D intensity)	3043	0.02	0.10	0	1.10	0.00	0.00	0.02	3315	0.001	0.003	0	0.05	0	0.00	0.00
RS (Innov intensity)	3043	0.02	0.11	0	1.11	0.00	0.00	0.03	3315	0.001	0.005	0	0.06	0	0.00	0.00
OI (% new to firm)	3043	7.16	20.98	0	100	0	0.0	18	3315	4.69	19.35	0	100	0	0	1
OI (% new to market)	3043	4.70	16.81	0	100	0	0.0	10	3315	1.42	9.38	0	100	0	0	0
OI (new to firm y/n)	1213	0.79	0.41	0	1	0	1	1	520	0.78	0.41	0	1	0	1	1
OI (new to market y/n)	1214	0.51	0.50	0	1	0	1	1	520	0.43	0.50	0	1	0	0	1
OI (process innov y/n)	3043	0.49	0.50	0	1	0	0	1	3315	0.27	0.44	0	1	0	0	1
OI (product innov y/n)	3043	0.39	0.49	0	1	0	0	1	3315	0.14	0.35	0	1	0	0	1
OI (service innov y/n)	3043	0.34	0.48	0	1	0	0	1	3315	0.10	0.30	0	1	0	0	0
No. of workers	3043	1131.55	2477.74	0	20727	221	441	2215	3315	1315.01	3865.11	5	41509	212	417	2026
Female workers	3043	45.36	23.21	0	100	17	41	80	3315	48.12	26.40	0	100	10	49	84
Type of firm																
Public	3032	0.09	0.29	0	1	0	0	0	3303	0.05	0.21	0	1	0	0	0
Private	3032	0.90	0.30	0	1	1	1	1	3303	0.95	0.21	0	1	1	1	1
Research association	3032	0.01	0.08	0	1	0	0	0	3303	0.00	0.02	0	1	0	0	0
Belongs to a group	3043	0.67	0.47	0	1	0	1	1	3315	0.62	0.48	0	1	0	1	1
New firm	3043	0.00	0.07	0	1	0	0	0	3315	0.00	0.03	0	1	0	0	0
Exports	3043	2.40	9.89	0	100	0	0	3.00	3315	7.01	19.29	0	100	0	0	23
Market of firm																
National	3043	0.77	0.42	0	1	0	1	1	3315	0.80	0.40	0	1	0	1	1
EU	3043	0.30	0.46	0	1	0	0	1	3315	0.46	0.50	0	1	0	0	1
Other countries	3043	0.20	0.40	0	1	0	0	1	3315	0.26	0.44	0	1	0	0	1
Cooperates	1945	0.44	0.50	0	1	0	0	1	1136	0.31	0.46	0	1	0	0	1

Source: Personal compilation based on PITEC data.

5 Econometric Strategy

5.1 Estimation Method

In this section we explain the econometric methods used to estimate the equations of the model referenced in section 3, equations (1)–(4).

First we estimate the probability of a firm carrying out innovation[10] activities using a Probit model, as per equation 1. The series of explanatory variables include the size of the firm (number of workers), percentage of female workers, a dummy variable indicating the type of firm (public, private or research association[11]), a dummy variable indicating whether the firm belongs to a group or not, a dummy variable indicating whether the firm is new (two years old or less), the percentage of sales that correspond to exports, dummy variables that indicate whether the firm operates in the national market, European Union market or other foreign country's market or not, and dummy variables indicating the year[12]. As a dependent variable we have a dummy variable that takes value one if the firm has positive innovation expenses and zero otherwise, as explained in section 3. The estimation of this first equation is of interest in itself, since it allows us to estimate the marginal effects of different explanatory variables on the probability of a firm engaging in innovation activities.

Then we estimate equation 2, the size of the innovation[13] using a linear regression model, since the size of innovation is only observed if the innovation expenses are positive. The equation includes the series of explanatory variables mentioned above. In this case, in addition to the previously mentioned explanatory variables, we also include a dummy variable that indicates whether the innovation is made in cooperation with other firm. This variable serves as an instrumental variable that identifies the equation. The dependent variable is the relative size of total innovation expenses, i.e., the intensity of innovation computed as total innovation expenses divided by the turnover of the firm.

The third equation,

$$OI_i = \gamma RS_i + \delta X_{3i} + u_{3i},$$

is the more complex one to estimate because we are dealing with the endogeneity of the innovation size OI and the variable exports. Furthermore, output innovation is thought to be intrinsically unobservable. However, we will assume that the percent of total sales that come from an innovative product can serve as a proxy for the process of transforming innovation expenses into "knowledge" and we will use this as our dependent variable. The explanatory variables used are the ones used to estimate equation (1), plus the

[10]Although the results discussed are for the estimation taking into account total innovation expenses, we have also obtained similar results by using R&D expenses; in both equations 1 and 2.

[11]The dummy variable indicating research association suffers from multicollinearity problems and is dropped in several occasions.

[12]Year 2003 is not included because it lacks information on several of the explanatory variables used.

[13]Again, we use total innovation expenses to calculate the intensity of innovation.

endogenous variable RS. Since OI is also only observed if the firm has positive innovation expenses, this equation is estimated using either a linear regression model if the variables are continuous (like in the case of percent of total sales that come from an innovative product, new to the firm or the market) or a Probit model if the variables are dummies (if the firm has a product that is new to the firm or new to the market, or if the firm has process innovation, product innovation, or service innovation)[14].

We also modelize the variable exports using equation (4). The set of explanatory variables includes the variables mentioned in equation (1) as well as an instrumental variable which is the mean of exports as a percentage of total sales across industry group[15] and year. This is done using a generalized Tobit model, since there is a large group of firm with zero exports.

Therefore, we have a system of four equations

$$\begin{cases} RD_i &= \beta_1 X_{1i} + u_{1i} \\ RS_i &= \beta_2 X_{2i} + u_{2i} \\ OI_i &= \gamma RS_i + \delta X_{3i} + u_{3i} \\ E_i &= \alpha X_{4i} + u_{4i} \end{cases}$$

that are estimated simultaneously to avoid problems with the error terms and endogeneity issues.

5.2 Estimation Results

We have estimated equations (1)–(4) using seven different variables as a measure of output innovation: (I) percentage of total sales that come from products new to the firm, (II) percentage of total sales that come from products new to the market, (III) if the firm has introduced a product that is new to the firm, (IV) if the firm has introduced a product that is new to the market, (V) if the firm has conducted process innovation, (VI) if the firm has conducted product innovation, and (VII) if the firm has conducted service innovation[16]. The first two are continuous variables and are therefore estimated using a linear regression model, while the last five are binary variables and thus estimated using a Probit model. These different estimations are conducted in order to understand the difference in innovation amongst subsectors.

[14]We have estimated equations (1)–(4) using seven different variables as a measure of output innovation: (I) percentage of total sales that come from products new to the firm, (II) percentage of total sales that come from products new to the market, (III) if the firm has introduced a product that is new to the firm, (IV) if the firm has introduced a product that is new to the market, (V) if the firm has conducted process innovation, (VI) if the firm has conducted product innovation, and (VII) if the firm has conducted service innovation. The first two are continuous variables and are therefore estimated using a linear regression model, while the last five are binary variables and thus estimated using a Probit model.

[15]See Appendix A.3 for industry groups used.

[16]We use these numbers to refer to these variables in the discussion of the results, in section 5.2.

Table 8: Estimation results of equation (3) **with subsectors as dummy variables**. Marginal effects.

VARIABLES	(I) % New Firm	(II) % New Market	(III) New Firm Y/N	(IV) New Market Y/N	(V) Process Innov	(VI) Product Innov	(VII) Service Innov
RS (Innov)	155.4*	319.8	5.672	5.819	5.705	5.942	5.558
No. of Workers (in logs)	−0.152	0.645	0.00282	0.00738	0.00815	0.00292	0.0155
Female Workers (% of workers)	0.0430*	−0.0488	−0.000327	−0.000686	−0.000641	−0.000556	−0.000597
Type of firm (ref: public)							
Private	−0.305	0.0969	−0.00182	−0.00392	−0.0140	−0.00742	−0.0275
Research Association	−96.43*	−234.6	−0.469	−0.419	−0.498	−0.478	−0.389
Belongs to group (ref: no)	−0.644	2.179	0.0290	0.0348	0.0360	0.0349	0.0263
New firm (ref: no)	18.41*	12.12	0.0378	0.0592	0.00966	0.0684	0.0319
Exports (% total sales)	0.0242	−0.00138	0.000341	−0.000224	−7.08e-05	0.000268	−0.000362
Year (ref: 2004)							
2005	2.091*	2.263	0.000786	0.00847	0.0102	−0.000989	−0.00131
2006	0.607	4.024	0.0255	0.0385	0.0456	0.0287	0.0212
2007	0.114	4.213	0.00592	0.0258	0.0185	0.0119	0.00648
2008	2.261*	4.069	0.0318	0.0436	0.0429	0.0343	0.0225
Subsector (ref: HT)							
LT	0.931	2.809	0.0830	0.0830	0.107	0.0845	0.0835
KIS	−5.987*	−4.949	−0.0767	−0.0926	−0.0699	−0.0828	−0.00294
NKIS	−1.601	−0.490	0.0286	0.00896	0.0414	0.00190	0.0414
N	16077	16077	16077	16077	16077	16077	16077
Log Likelihood	−68441	−66656	−38582	−38268	−37153	−37938	−37989

Table 9: Estimation results of equation (3) for **HT manufacturing industries**. Marginal effects.

VARIABLES	(I) % New Firm	(II) % New Market	(III) New Firm Y/N	(IV) New Market Y/N	(V) Process Innov	(VI) Product Innov	(VII) Service Innov
RS (Innov)	200.8	284.0	8.246	9.117	7.439	9.137	7.915
No. of Workers (in logs)	0.658	2.961	−0.00489	0.0267	0.0251	0.0237	0.0303
Female Workers (% of workers)	−0.0804	−0.0939	−0.00271	−0.00268	−0.00243	−0.00246	−0.00253
Type of firm (ref: public)							
Private	−9.324	0.649	−0.00563	0.101	0.204	0.101	0.0352
Belongs to group (ref: no)	−0.108	−3.678	0.0201	−0.0625	0.0206	−0.0507	−0.0120
New firm (ref: no)	5.346	17.61	0.284	0.408	0	0.212	0
Exports (% total sales)	−0.0228	−0.0838	−0.00397	−0.00431	−0.00375	−0.00446	−0.00470
Year (ref: 2004)							
2005	1.787	1.420	−0.0259	−0.00423	−0.0214	−0.0392	−0.0473
2006	0.194	1.528	−0.0566	−0.00170	−5.37e-05	−0.0573	−0.0580
2007	−1.593	2.522	−0.0830	−0.0162	−0.0251	−0.0649	−0.0784
2008	1.100	1.153	−0.0813	−0.0322	−0.0590	−0.0746	−0.141
N	2377	2377	2377	2377	2377	2377	2377
Log Likelihood	−15965	−15639	−8081	−8155	−7868	−7688	−7976

Table 10: Estimation results of equation (3) for **LT manufacturing industries**. Marginal effects.

VARIABLES	(I) % New Firm	(II) % New Market	(III) New Firm Y/N	(IV) New Market Y/N	(V) Process Innov	(VI) Product Innov	(VII) Service Innov
RS (Innov)	152.2	24.57	2.210	1.476	1.760	1.922	0.965
No. of Workers (in logs)	−1.400	−0.194	0.0271	0.0600	0.0209	0.0375	0.0752
Female Workers (% of workers)	0.0620	0.0224	0.00157	0.00147	−4.45e-06	0.00179	0.00111
Type of firm (ref: public)							
Private	−4.034	−0.217	−0.197	−0.107	0.0921	−0.111	−0.216
Research Association	−11.60	−10.09	0	0	0	0	0
Belongs to group (ref: no)	−2.411	1.222	0.0253	0.0554	0.0268	0.0507	0.00280
New firm (ref: no)	18.88	−1.180	0.200	0.0834	0	0	−0.0347
Exports (% total sales)	0.0112	0.0306	0.000584	−0.000658	0.000870	0.000212	0.000791
Year (ref: 2004)							
2005	2.101	4.551	−0.0168	0.0680	0.0136	0.0118	−0.00522
2006	0.639	4.178	0.0202	0.0660	0.0554	0.0242	0.00319
2007	2.533	4.773	−0.0108	0.0573	0.0289	−0.00450	−0.00885
2008	3.289	5.328	−0.00368	0.0342	0.0578	−0.00742	−0.00993
N	3606	3606	3606	3606	3606	3606	3606
Log Likelihood	−19644	−19041	−10431	−10419	−9889	−10237	−10212

Table 11: Estimation results of equation (3) for **KIS**. Marginal effects.

VARIABLES	(I) % New Firm	(II) % New Market	(III) New Firm Y/N	(IV) New Market Y/N	(V) Process Innov	(VI) Product Innov	(VII) Service Innov
RS (Innov)	98.90	125.4	2.809	2.796	2.870	2.920	2.834
No. of Workers (in logs)	−0.322	1.183	0.0100	0.0175	0.00620	0.0118	0.0133
Female Workers (% of workers)	0.00214	−0.0842	−0.000386	−0.00112	−0.000651	−0.000698	−0.000752
Type of firm (ref: public)							
Private	−1.146	0.553	−0.0123	−0.0106	−0.0490	−0.0139	−0.0241
Research Association	−53.25	−84.29	−0.396	−0.351	−0.456	−0.419	−0.393
Belongs to group (ref: no)	0.0822	6.230	0.0571	0.0807	0.0685	0.0680	0.0733
New firm (ref: no)	5.071	27.36	−0.00674	0.0849	−0.0331	0.0438	0.0624
Exports (% total sales)	−0.349	−0.169	−0.00894	−0.00725	−0.00925	−0.00863	−0.00874
2005	1.754	2.869	0.00165	0.0165	0.0238	0.00282	0.0105
2006	0.407	5.601	0.00914	0.0343	0.0495	0.0178	0.0240
2007	−0.934	5.361	−0.0360	−0.00186	−0.0106	−0.0201	−0.0129
2008	4.208	3.840	0.0322	0.0400	0.0543	0.0312	0.0371
N	3032	3032	3032	3032	3032	3032	3032
Log Likelihood	−10993	−10738	−4872	−4743	−4596	−4756	−4794

Table 12: Estimation results of equation (3) for **NKIS**. Marginal effects.

VARIABLES	(I) % New Firm	(II) % New Market	(III) New Firm Y/N	(IV) New Market Y/N	(V) Process Innov	(VI) Product Innov	(VII) Service Innov
RS (Innov)	−248.2	27.46	39.00	4.477	41.42	2.880	40.67
No. of Workers (in logs)	0.349	0.405	0.00903	0.0368	0.000144	0.0379	0.00617
Female Workers (% of workers)	0.146	−0.0426	0.000274	−0.00175	0.000505	−0.00138	0.000393
Type of firm (ref: public)							
Private	−2.629	−5.176	0.112	−0.0984	0.157	−0.247	0.119
Research Association	0	0	0	0	0	0	0
Belongs to group (ref: no)	−2.675	4.697	0.0315	0.0956	0.0489	0.0159	0.0398
New firm (ref: no)	−8.300	−4.129	0	0.294	0	0.102	0
Exports (% total sales)	−0.147	−0.0591	−0.00796	−0.00129	−0.00857	−0.000529	−0.00829
Year (ref: 2004)							
2005	6.845	−0.688	−0.0244	−0.0183	−0.0474	0.0558	−0.0379
2006	−3.810	1.136	−0.103	−0.0262	−0.106	−0.0335	−0.104
2007	−0.559	1.491	−0.120	0.00687	−0.131	0.0234	−0.122
2008	−2.490	1.640	−0.122	0.0422	−0.136	0.0357	−0.120
N	3303	3303	3303	3303	3303	3303	3303
Log Likelihood	−8052	−7702	−5308	−5210	−5191	−5318	−5249

Tables 8–12 only show the estimation results for the output innovation equation, that is, equation (3) because this is the one that is of most interest to us[17]. Furthermore, the results shown are the marginal effects; the coefficients with their corresponding standard deviations are available in Annex A.1.

If we check Tables 8 and 16 we see that the dummy variables corresponding to the subsectors are significant for most of the variables used as OI, which suggests that there are differences across HT, LT, KIS and NKIS like we proposed in the motivation. We now focus on Tables 9–12 to see in detail what these differences are:

- Research size has no effect on the % of total sales from products new to the firm (I) nor new to the market (II) across subsectors. It does, however, have a positive effect on the other variables used as OI (the exception being subsector LT). This suggests that research size has a positive impact on innovation, but not on the increase in sales derived from this innovation.

- Research size does not affect the percentage of total sales from products new to the firm nor new to the market, for almost none of the subsectors (and this effect is negligible). The other explanatory variables used are not significant either, which suggests that using variables (I) and (II) as a measure of output innovation is not such a good idea after all.

- We obtain much better results by using whether a firm has introduced a product new to the firm as a binary variable. Research size has a positive effect on introducing products new to the firm; and the size of this effect is different for each subsector (8.43 for HT, non significant for LT, 2.81 for KIS, 39.00 for NKIS). We had expected research size to have a greater effect on variable (III) for HT and KIS, but not so big as the one obtained for NKIS. However, we must be careful and take these results with a grain of salt, since introducing a product new to the firm might not be considered by some a "true" measure of innovation, thus the strange results.

- If we take a look at the results obtained with the introduction of a product new to the market, variable (IV), which is a narrower (and perhaps more accurate) definition of innovation, we see that research size has no effect on LT nor on NKIS. Furthermore, the effect on HT and KIS is positive, but the size varies: an increase of 1% in the research size results in a 9.11% increase in the probability of HT firms introducing a product new to the firm, and only in a 2.80% increase in the probability of KIS firms doing so. This suggests that, to answer our initial question, **innovation in differs across the level of technology or knowledge, but also between sectors (manufacturing industry and services)**.

- We were expecting the following results from the last three columns: for research size to have a larger effect on "technological" output innovation, that is, on product

[17] The general results (with subsectors as dummy variables), in marginal effects, for the other three equations are included in Appendix A.1.

and process innovation, for manufacturing industries than for services, and viceversa in the case of "non-technological" service innovation. A quick glance at Tables 9–12 and 17–20 (available in Annex A.1) tells us this is not the case.

- Now, if we compare the significance and size of the effect of research size on each measure of output innovation, we can see that this effect is almost constant for HT and KIS firms; although consistently bigger for HT manufacturing industries. In the case of LT, is it non-significant for all seven variables used. NKIS firms have the most variance in the size of the effect throughout all seven variables: research size has a huge effect on process and service innovation, as well as on the probability of introducing products new to the firm.
- Exports (as a percentage of total sales), the explanatory variable of most interest to us, has mixed results: it has a negative effect (although the size of the effect varies among subsectors) on output innovation for HT, KIS and NKIS firms, and is non-significant for LT firms. That is, an increase in the percentage of exports out of total sales decreases the probability of engaging in innovation activities. Since the variable exports is endogenous and is estimated as such, we have isolated the effect of exports on innovation, but we do not know the effect of innovation on exports. It could very well be that an increase in innovation expands a firm's market and results in an increase in exports, having a net effect that is positive. This would explain the results obtained previously, in which exports was not taken into account as an endogenous variable, and had a positive coefficient when estimating output innovation.
- Regarding the other explanatory variables, we obtain varied results as well. The number of workers seems to have a positive effect in some cases, and none whatsoever in others. This might be because the sample is restricted to big firms. The percentage of female workers has a negative effect in the case of HT firms, a negative effect in the case of LT firms, and is non-significant in the case of services. Services is a predominantly female sector, while the opposite happens in the industry; especially in HT when compared to LT manufacturing industry firms. The effect shown might capturing some of this issues of unbalanced male/female population. The effect of other variables on output innovation is negligible.

In short, we can see that there are, in fact, differences between sectors and even among them. However, these differences might not be as big as we initially thought: the determining variables of innovation are the same and the direction of the effect is almost always the same as well; it is the *size* of the effect that is different.

Furthermore, the results obtained have a policy implication: if the objective is an innovative economy, then it is clear; the Government should promote expenditure on innovation. If, however, the goal is to obtain more sales, an increase on the size of expenditure does not seem to help this cause. We should, however, take into account that research size has no effect on LT when implementing the policy of promoting expenditure on innovation.

6 Conclusions

The aim of this paper was to study the driving forces of innovation of the Spanish economy, differing between subsectors, using a simplified CDM model to check whether the innovation was the same for manufacturing industries and services, and/or whether it differed across level of technology or knowledge. In order to do this, we have used data on innovation by Spanish firms collected by PITEC. Although the initial analysis in sections 2 and 4 suggests that there are indeed differences which must be accounted for, the analysis conducted in section 5 using the model described in section 3 suggests that the differences are not as big as we thought.

In short, we have found that although the determining variables are practically the same for all subsectors and the direction of the effect is similar, it is the size of the effect that varies among subsectors. That is, differences between manufacturing industries exists – we just have to see the tables that summarize the main results – but they might not be as big as we thought after checking the data in the Motivation section.

Innovation intensity does have a positive effect on output innovation (except on Low-Tech Manufacturing Industries, on which it has no effect). The size of this effect varies depending on the subsector; it is bigger for High-Tech Manufacturing Industries than for Knowledge Intensive Services, and even smaller for Non-Knowledge Intensive Services; which is in agreement with other papers on the topic. These results suggest a possible innovation policy: if the objective of the policy is for Spain to be a more innovative economy, then the Government should promote expenditure on innovation. We should, however, take into account that research size has no effect on Low-Tech Manufacturing Industries and act accordingly when implementing said policy.

On the other hand, we would like to expand the analysis to include equation (5) as well to see how this changes the results already obtained; although this poses additional issues of endogeneity and therefore, possible problems with the error terms. Plus, it might require information on capital investment which is not always readily available. Another possible extension is to include small firms in the estimation to see how these behave differently from big firms. Perhaps it would be interesting to use other countries' data to conduct the same analysis: since Spain is not a cutting edge innovator the results will more than likely vary widely.

However, even if we extend the analysis to include the fourth equation, smaller firms, and other countries, there is still one major problem: benchmarking innovation is difficult, so we might not obtain the results we expect because of this. The reasons why measuring innovation is extremely hard are varied, but we will just comment on a few of them: innovation is closely related to strategy; and unless you share a common strategy with another firm, you can not benchmark nor mimic their processes. On top of that, innovation is time-sensitive, in the sense that a firm's planning horizon differs vastly from any other firm: some firms consider time periods of decades, while others think that anything longer than 90 days ahead of time is overkill. Also, innovation is dictated by wants or needs of jobs that need to be done, or technology vision: while some firms ignore customer needs, others do an enormous amount of customer research (if you would have asked anyone hundreds of years ago what they needed to fulfill their automobile needs, they probably would have answered “a faster horse”, not a car). And perhaps most important of it all, the way innovation is measured in surveys – through investment in R&D and expenses in innovation – might not be the best way to measure it, it might just be the easiest to quantify. A firm might have a great idea on how to improve their products, or their marketing, and might not have spent a dime on it.

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A Appendix

A.1 Other tables of results

Tables 13, 14 and 15 show the determinant factors of exports (as a percentage of total sales), and those involved in the decision to conduct innovation and the innovation size (or intensity) respectively.

We can see in Table 13 that the variable Exports mean by activity correctly identifies this equation in order for Exports to be treated as an endogenous variables. Furthermore, it has (as expected) a positive effect on exports. All explanatory variables have the expected effect on exports; and we can see that the size of the effect varies depending on the way we measure output innovation. Also, Tables 14 and 15 show that the variable Cooperates also correctly identifies the corresponding equation; and again, the explanatory variables have the expected effect.

Table 13: Estimation results of equation (1) **with subsectors as dummy variables**. Marginal effects.

Dependent variable: Exports (% of total sales)

VARIABLES	(I) % New Firm	(II) % New Market	(III) New Firm Y/N	(IV) New Market Y/N	(V) Process Innov Y/N	(VI) Product Innov Y/N	(VII) Service Innov Y/N
Female Workers (% of workers)	−0.0494*	−0.0498*	−0.0495*	−0.0502*	−0.0498*	−0.0492*	−0.0501*
Type of firm (ref: public)							
Private	8.078*	8.049*	8.002*	8.064*	8.036*	8.064*	8.111*
Research Association	19.00	19.42	19.67	20.23	19.41	19.82	20.03
Belongs to group (ref: no)	5.964*	5.985*	5.977*	6.002*	5.982*	5.968*	5.973*
New firm (ref: no)	−9.735	−9.588	−9.646	−9.741	−9.857	−9.722	−9.248
Exports mean by activity	2.862*	2.860*	2.867*	2.858*	2.863*	2.866*	2.862*
Year (ref: 2004)							
2005	1.475	1.459	1.485	1.470	1.492	1.490	1.507
2006	7.479*	7.463*	7.553*	7.470*	7.524*	7.539*	7.520*
2007	3.229*	3.219*	3.299*	3.226*	3.255*	3.288*	3.294*
2008	6.014*	5.985*	6.082*	5.978*	6.039*	6.069*	6.064*
Subsector (ref: HT)							
LT	10.53*	10.55*	10.49*	10.58*	10.55*	10.49*	10.55*
KIS	1.013	0.985	1.029	0.982	1.067	1.042	1.070
NKIS	2.001	2.020	1.817	1.798	1.742	1.871	1.942
N	16077	16077	16077	16077	16077	16077	16077
Log Likelihood	−68441	−66656	−38565	−38271	−37169	−37940	−37985

* indicates p-value< 0.1

Table 14: Estimation results of equation (2) **with subsectors as dummy variables**. Marginal effects.

Dependent variable: RD (Innov)

VARIABLES	(I) % New Firm	(II) % New Market	(III) New Firm Y/N	(IV) New Market Y/N	(V) Process Innov Y/N	(VI) Product Innov Y/N	(VII) Service Innov Y/N
No. of Workers (in logs)	0.0681	0.0673	0.0649	0.0649	0.0667	0.0644	0.0642
Female Workers (% of workers)	−0.00188	−0.00187	−0.00187	−0.00188	−0.00188	−0.00186	−0.00186
Type of firm (ref: public)							
Private	−0.187	−0.186	−0.186	−0.181	−0.187	−0.185	−0.187
Research Association	−0.380	−0.323	−0.397	−0.397	−0.370	−0.397	−0.397
Belongs to group (ref: no)	0.126	0.125	0.125	0.124	0.126	0.125	0.125
New firm (ref: no)	0.291	0.300	0.293	0.293	0.295	0.293	0.295
Exports (% of total sales)	0.00540	0.00540	0.00531	0.00539	0.00538	0.00528	0.00531
Year (ref: 2004)							
2005	0.0188	0.0190	0.0200	0.0193	0.0180	0.0204	0.0199
2006	0.0448	0.0448	0.0448	0.0450	0.0446	0.0445	0.0454
2007	0.0378	0.0371	0.0371	0.0373	0.0372	0.0361	0.0372
2008	0.0788	0.0790	0.0791	0.0798	0.0782	0.0786	0.0791
Subsector (ref: HT)							
LT	0.157	0.158	0.157	0.158	0.157	0.158	0.156
KIS	0.0866	0.0848	0.0822	0.0813	0.0837	0.0827	0.0801
NKIS	−0.223	−0.224	−0.218	−0.219	−0.221	−0.217	−0.218
N	16077	16077	16077	16077	16077	16077	16077
Log Likelihood	−68441	−66656	−38565	−38271	−37169	−37940	−37985

Table 15: Estimation results of equation (4) **with subsectors as dummy variables**. Marginal effects.

Dependent variable: RS (Innov)

VARIABLES	(I) % New Firm	(II) % New Market	(III) New Firm Y/N	(IV) New Market Y/N	(V) Process Innov Y/N	(VI) Product Innov Y/N	(VII) Service Innov Y/N
Female Workers (% of workers)	$9.00e-05^{*}$	$9.97e-05^{*}$	0.000115*	0.000112*	0.000101*	0.000118*	0.000120
Type of firm (ref: public)							
Private	0.00175	0.00247	0.00435	0.00384	0.00302	0.00436	0.00468
Research Association	0.756*	0.759*	0.766*	0.771*	0.758*	0.763*	0.770
Belongs to group (ref: no)	−0.00359	−0.00413*	−0.00522*	−0.00468*	−0.00437*	−0.00528*	−0.00543
New firm (ref: no)	−0.000177	−0.000999	−0.00297	−0.00241	−0.00154	−0.00297	−0.00336
Exports (% of total sales)	6.12e-05	4.50e-05	1.00e-05	1.73e-05	3.20e-05	6.97e-06	−2.00e-06
Cooperates (ref: no)	0.00959*	0.00912*	0.00833*	0.00858*	0.00890*	0.00823*	0.00812
Year (ref: 2004)							
2005	0.000814	0.000679	0.000609	0.000788	0.000532	0.000582	0.000592
2006	−0.00295	−0.00336	−0.00384	−0.00374	−0.00355	−0.00384	−0.00396
2007	−0.000348	−0.000780	−0.000948	−0.000923	−0.000846	−0.00103	−0.00104
2008	−0.00232	−0.00308	−0.00423	−0.00403	−0.00355	−0.00428	−0.00456
Subsector (ref: HT)							
LT	−0.0133*	−0.0137*	−0.0143*	−0.0141*	−0.0138*	−0.0143*	−0.0145
KIS	0.0119*	0.0120*	0.0126*	0.0123*	0.0123*	0.0123*	0.0124
NKIS	−0.00795	−0.00707	−0.00704	−0.00898	−0.0113	−0.00622	−0.00568
N	16077	16077	16077	16077	16077	16077	16077
Log Likelihood	−68441	−66656	−38565	−38271	−37169	−37940	−37985

* indicates p-value< 0.1

Table 16: Estimation results of equation (3) **with subsectors as dummy variables**. Coefficients.

Dependent variable: OI

VARIABLES	(I) % New Firm	(II) % New Market	(III) New Firm Y/N	(IV) New Market Y/N	(V) Process Innov	(VI) Product Innov	(VII) Service Innov
RS (Innov)	155.4*	319.8*	14.28*	14.94*	14.30*	14.93*	14.56*
	(75.87)	(98.61)	(0.435)	(0.200)	(0.314)	(0.154)	(0.271)
No. of Workers (in logs)	−0.152	0.645*	0.00710	0.0190*	0.0204*	0.00735	0.0405*
	(0.347)	(0.245)	(0.00586)	(0.00706)	(0.00741)	(0.00459)	(0.0124)
Female Workers (% of workers)	0.0430*	−0.0488*	−0.000824	−0.00176*	−0.00161*	−0.00140*	−0.00156*
	(0.0169)	(0.0212)	(0.000728)	(0.000728)	(0.000716)	(0.000730)	(0.000730)
Type of firm (ref: public)							
Private	−0.305	0.0969	−0.00458	−0.0101	−0.0351	−0.0186	−0.0713
	(1.522)	(1.398)	(0.0526)	(0.0498)	(0.0511)	(0.0500)	(0.0517)
Research Association	−96.43*	−234.6*	−10.69*	−11.35*	−11.03*	−11.35*	−11.13*
	(57.42)	(75.40)	(0.376)	(0.216)	(0.261)	(0.157)	(0.240)
Belongs to group (ref: no)	−0.644	2.179*	0.0730*	0.0896*	0.0903*	0.0878*	0.0691*
	(0.829)	(0.920)	(0.0379)	(0.0388)	(0.0391)	(0.0374)	(0.0355)
New firm (ref: no)	18.41*	12.12	0.0948	0.150	0.0242	0.172	0.0826
	(4.287)	(9.024)	(0.266)	(0.293)	(0.290)	(0.311)	(0.282)
Exports (% total sales)	0.0242	−0.00138	0.000858	−0.000575	−0.000178	0.000674	−0.000947
	(0.0263)	(0.0312)	(0.00130)	(0.00120)	(0.00121)	(0.00127)	(0.00118)
Year (ref: 2004)							
2005	2.091*	2.263*	0.00198	0.0217	0.0255	−0.00249	−0.00343
	(0.971)	(1.080)	(0.0375)	(0.0391)	(0.0392)	(0.0372)	(0.0367)
2006	0.607	4.024*	0.0640	0.0982*	0.114*	0.0721	0.0553
	(1.105)	(1.240)	(0.0459)	(0.0467)	(0.0487)	(0.0461)	(0.0453)
2007	0.114	4.213*	0.0149	0.0659	0.0463	0.0299	0.0169
	(1.137)	(1.154)	(0.0407)	(0.0444)	(0.0426)	(0.0405)	(0.0399)
2008	2.261*	4.069*	0.0799*	0.111*	0.108*	0.0860*	0.0586
	(1.120)	(1.230)	(0.0465)	(0.0489)	(0.0482)	(0.0453)	(0.0436)
Subsector (ref: HT)							
LT	0.931	2.809	0.209*	0.211*	0.268*	0.212*	0.216*
	(1.458)	(2.038)	(0.0715)	(0.0703)	(0.0716)	(0.0727)	(0.0698)
KIS	−5.987*	−4.949*	−0.195*	−0.243*	−0.176*	−0.210*	−0.00771
	(1.407)	(1.781)	(0.0427)	(0.0412)	(0.0442)	(0.0415)	(0.0746)
NKIS	−1.601	−0.490	0.0718	0.0230	0.104	0.00478	0.107
	(2.453)	(4.324)	(0.215)	(0.198)	(0.188)	(0.195)	(0.186)
Constant	8.403*	−7.555*	−0.552*	−0.732*	−0.554*	−0.509*	−0.895*
	(3.829)	(4.014)	(0.0819)	(0.0961)	(0.0787)	(0.0737)	(0.127)
N	16077	16077	16077	16077	16077	16077	16077
Log Likelihood	−68441	−66656	−38582	−38268	−37153	−37938	−37989

Standard error in parentheses

* indicates p-value< 0.1

Table 17: Estimation results of equation (3) for **HT manufacturing industries**. Coefficients.

Dependent variable: OI

VARIABLES	(I) % New Firm	(II) % New Market	(III) New Firm Y/N	(IV) New Market Y/N	(V) Process Innov	(VI) Product Innov	(VII) Service Innov
RS (Innov)	200.8	284.0*	21.27*	22.86*	20.01*	25.15*	21.38*
	(132.5)	(123.3)	(2.013)	(1.849)	(2.282)	(1.411)	(2.071)
No. of Workers (in logs)	0.658	2.961*	−0.0126	0.0669*	0.0674*	0.0651*	0.0819*
	(0.767)	(0.644)	(0.0251)	(0.0260)	(0.0289)	(0.0251)	(0.0284)
Female Workers (% of workers)	−0.0804	−0.0939*	−0.00700*	−0.00671*	−0.00654*	−0.00678*	−0.00684*
	(0.0544)	(0.0440)	(0.00156)	(0.00155)	(0.00162)	(0.00155)	(0.00165)
Type of firm (ref: public)							
Private	−9.324	0.649	−0.0146	0.257	0.520*	0.265	0.0969
	(10.15)	(5.808)	(0.349)	(0.320)	(0.252)	(0.352)	(0.297)
Belongs to group (ref: no)	−0.108	−3.678*	0.0517	−0.157	0.0550	−0.143	−0.0322
	(2.076)	(1.906)	(0.0997)	(0.105)	(0.103)	(0.105)	(0.100)
New firm (ref: no)	5.346	17.61	0.928	1.287		0.737	
	(148.0)	(118.0)	(2.133)	(2.870)		(2.338)	
Exports (% total sales)	−0.0228	−0.0838	−0.0102*	−0.0108*	−0.0101*	−0.0123*	−0.0127*
	(0.118)	(0.0976)	(0.00368)	(0.00405)	(0.00409)	(0.00366)	(0.00391)
Year (ref: 2004)							
2005	1.787	1.420	−0.0665	−0.0106	−0.0572	−0.107	−0.130*
	(1.849)	(1.660)	(0.0772)	(0.0761)	(0.0787)	(0.0764)	(0.0755)
2006	0.194	1.528	−0.145	−0.00427	−0.000144	−0.155	−0.160
	(2.491)	(2.263)	(0.0997)	(0.103)	(0.110)	(0.0965)	(0.0992)
2007	−1.593	2.522	−0.211*	−0.0407	−0.0671	−0.175	−0.219*
	(2.988)	(2.505)	(0.111)	(0.119)	(0.124)	(0.113)	(0.116)
2008	1.100	1.153	−0.207	−0.0808	−0.156	−0.201	−0.404*
	(3.882)	(3.210)	(0.134)	(0.152)	(0.151)	(0.138)	(0.136)
Constant	17.75	−11.05	0.189	−0.785*	−0.733*	−0.265	−0.935*
	(12.06)	(8.400)	(0.444)	(0.398)	(0.357)	(0.417)	(0.386)
N	2377	2377	2377	2377	2377	2377	2377
Log Likelihood	−15965	−15639	−8081	−8155	−7868	−7688	−7976

Standard error in parentheses

* indicates p-value< 0.1

Table 18: Estimation results of equation (3) for **LT manufacturing industries**. Coefficients.

Dependent variable: OI

VARIABLES	(I) % New Firm	(II) % New Market	(III) New Firm Y/N	(IV) New Market Y/N	(V) Process Innov	(VI) Product Innov	(VII) Service Innov
RS (Innov)	152.2	24.57	5.613	3.773	7.020	5.599	2.930
	(720.7)	(458.0)	(30.52)	(30.57)	(40.55)	(34.41)	(732.47)
No. of workers (in logs)	−1.400	−0.194	0.0689	0.153*	0.0833	0.109*	0.228*
	(0.954)	(0.666)	(0.0437)	(0.0442)	(0.0515)	(0.0474)	(0.0468)
Female workers (% of workers)	0.0620*	0.0224	0.00398*	0.00377*	−1.77e-05	0.00522*	0.00337*
	(0.0341)	(0.0247)	(0.00152)	(0.00154)	(0.00185)	(0.00161)	(0.00161)
Type of firm (ref: public)							
Private	−4.034	−0.217	−0.548	−0.269	0.320	−0.363	−0.580
	(14.97)	(10.31)	(0.721)	(0.738)	(0.912)	(0.833)	(0.782)
Research Association	−11.60	−10.09					
	(0)	(0)					
Belongs to group (ref: no)	−2.411*	1.222	0.0641	0.143*	0.104	0.145*	0.00853
	(1.281)	(1.054)	(0.0647)	(0.0653)	(0.0784)	(0.0680)	(0.0704)
New firm (ref: no)	18.88*	−1.180	0.559	0.210			−0.109
	(8.714)	(407.3)	(1.862)	(1.282)			(1.346)
Exports (% total sales)	0.0112	0.0306	0.00148	−0.00168	0.00347	0.000617	0.00240
	(0.0941)	(0.0677)	(0.00424)	(0.00426)	(0.00532)	(0.00462)	(0.00450)
Year (ref: 2004)							
2005	2.101	4.551*	−0.0426	0.173	0.0549	0.0346	−0.0159
	(3.002)	(2.078)	(0.132)	(0.132)	(0.170)	(0.143)	(0.140)
2006	0.639	4.178*	0.0513	0.167	0.237*	0.0712	0.00967
	(2.420)	(1.973)	(0.112)	(0.113)	(0.137)	(0.120)	(0.118)
2007	2.533	4.773*	−0.0275	0.145	0.120	−0.0131	−0.0270
	(2.263)	(2.002)	(0.106)	(0.106)	(0.128)	(0.111)	(0.113)
2008	3.289	5.328*	−0.00935	0.0871	0.249	−0.0215	−0.0303
	(2.774)	(2.156)	(0.130)	(0.131)	(0.164)	(0.140)	(0.140)
Constant	21.37	3.411	0.0435	−1.185	−0.207	−0.0918	−1.567
	(22.77)	(15.11)	(1.016)	(1.032)	(1.317)	(1.169)	(1.097)
N	3606	3606	3606	3606	3606	3606	3606
Log Likelihood	−19644	−19041	−10431	−10419	−9889	−10237	−10212

Standard error in parentheses

* indicates p-value< 0.1

Table 19: Estimation results of equation (3) for **KIS**. Coefficients.

Dependent variable: OI

VARIABLES	(I) % New Firm	(II) % New Market	(III) New Firm Y/N	(IV) New Market Y/N	(V) Process Innov	(VI) Product Innov	(VII) Service Innov
RS (Innov)	98.90	125.4	7.354*	7.635*	7.268*	7.530*	7.440*
	(80.04)	(85.34)	(0.380)	(0.208)	(0.341)	(0.203)	(0.212)
No. of Workers (in logs)	−0.322	1.183*	0.0262*	0.0478*	0.0157	0.0305*	0.0350*
	(0.723)	(0.513)	(0.0154)	(0.0277)	(0.0127)	(0.0181)	(0.0198)
Female Workers (% of workers)	0.00214	−0.0842*	−0.00101	−0.00305	−0.00165	−0.00180	−0.00197
	(0.0381)	(0.0453)	(0.00172)	(0.00223)	(0.00180)	(0.00187)	(0.00194)
Type of firm (ref: public)							
Private	−1.146	0.553	−0.0321	−0.0287	−0.123	−0.0358	−0.0629
	(2.549)	(2.797)	(0.105)	(0.114)	(0.112)	(0.108)	(0.106)
Research Association	−53.25	−84.29	−5.404*	−5.525*	−5.560*	−5.540*	−5.492*
	(60.59)	(64.90)	(0.409)	(0.320)	(0.275)	(0.263)	(0.262)
Belongs to group (ref: no)	0.0822	6.230*	0.151*	0.224*	0.175*	0.177*	0.195*
	(2.376)	(2.615)	(0.0763)	(0.0889)	(0.0789)	(0.0800)	(0.0828)
New firm (ref: no)	5.071	27.36	−0.0177	0.223	−0.0844	0.112	0.161
	(10.73)	(23.76)	(0.661)	(0.836)	(0.670)	(0.714)	(0.725)
Exports (% total sales)	−0.349	−0.169	−0.0234*	−0.0198*	−0.0234*	−0.0223*	−0.0230*
	(0.245)	(0.252)	(0.00351)	(0.00349)	(0.00360)	(0.00331)	(0.00349)
Year (ref: 2004)							
2005	1.754	2.869	0.00431	0.0448	0.0601	0.00727	0.0274
	(2.187)	(2.268)	(0.0808)	(0.0869)	(0.0891)	(0.0802)	(0.0806)
2006	0.407	5.601*	0.0239	0.0926	0.125	0.0458	0.0626
	(2.561)	(2.404)	(0.101)	(0.102)	(0.107)	(0.101)	(0.100)
2007	−0.934	5.361*	−0.0952	−0.00509	−0.0268	−0.0520	−0.0341
	(2.754)	(2.492)	(0.0840)	(0.0966)	(0.0906)	(0.0842)	(0.0862)
2008	4.208*	3.840	0.0837	0.108	0.137	0.0800	0.0966
	(2.420)	(2.681)	(0.100)	(0.101)	(0.107)	(0.0977)	(0.100)
Constant	4.979	−12.13	−0.763*	−1.042*	−0.498*	−0.733*	−0.815*
	(8.504)	(8.771)	(0.187)	(0.276)	(0.190)	(0.176)	(0.191)
N	3032	3032	3032	3032	3032	3032	3032
Log Likelihood	−10993	−10738	−4872	−4743	−4596	−4756	−4794

Standard error in parentheses

* indicates p-value< 0.1

Table 20: Estimation results of equation (3) for **NKIS**. Coefficients.

VARIABLES	(I) % New Firm	(II) % New Market	(III) New Firm Y/N	(IV) New Market Y/N	(V) Process Innov	(VI) Product Innov	(VII) Service Innov
RS (Innov)	-248.2	27.46	100.5*	17.32	104.0*	7.532	103.6*
	(7,035)	(5,553)	(10.60)	(402.8)	(3.005)	(371.9)	(3.211)
No. of Workers (in logs)	0.349	0.405	0.0233	0.142	0.000362	0.0990*	0.0157
	(1.233)	(0.740)	(0.0567)	(0.0920)	(0.00387)	(0.0510)	(0.0373)
Female Workers (% of workers)	0.146	−0.0426	0.000706	−0.00679	0.00127	−0.00360	0.00100
	(0.100)	(0.114)	(0.00205)	(0.00898)	(0.00156)	(0.00553)	(0.00168)
Type of firm (ref: public)							
Private	−2.629	−5.176	0.303	−0.335	0.407*	−0.629	0.315
	(28.29)	(22.75)	(0.328)	(1.912)	(0.153)	(1.683)	(0.261)
Belongs to group (ref: no)	−2.675	4.697	0.0815	0.387	0.123	0.0417	0.102
	(7.390)	(6.390)	(0.117)	(0.242)	(0.137)	(0.384)	(0.114)
New firm (ref: no)	−8.300	−4.129		0.857		0.259	
	(0)	(0)		(0)		(0)	
Exports (% total sales)	−0.147	−0.0591	−0.0205*	−0.00497	−0.0215*	−0.00138	−0.0211*
	(1.608)	(1.268)	(0.00484)	(0.0968)	(0.00311)	(0.0899)	(0.00254)
Year (ref: 2004)							
2005	6.845	−0.688	−0.0631	−0.0723	−0.119	0.144	−0.0971
	(8.505)	(6.880)	(0.226)	(0.501)	(0.150)	(0.523)	(0.165)
2006	−3.810	1.136	−0.273*	−0.104	−0.268*	−0.0883	−0.271*
	(21.74)	(16.33)	(0.160)	(1.272)	(0.154)	(1.196)	(0.151)
2007	−0.559	1.491	−0.319	0.0264	−0.334*	0.0608	−0.319*
	(26.37)	(20.20)	(0.209)	(1.695)	(0.165)	(1.529)	(0.181)
2008	−2.490	1.640	−0.326*	0.156	−0.347*	0.0925	−0.315*
	(26.28)	(21.05)	(0.192)	(1.773)	(0.156)	(1.550)	(0.175)
Constant	7.256	6.554	−1.055*	−1.494	−0.877*	−0.244	−1.000*
	(62.44)	(49.59)	(0.411)	(2.831)	(0.188)	(3.243)	(0.278)
N	3303	3303	3303	3303	3303	3303	3303
Log Likelihood	−8052	−7702	−5308	−5210	−5191	−5318	−5249

Standard error in parentheses

* indicates p-value< 0.1

A.2 Glossary

The following glossary is meant to clarify and define a series of terms and variables used throughout the rest of the text.

Belongs to group Dummy variable that takes value one if the firm belongs to a cluster of firms or zero otherwise.

Community Innovation Surveys (CIS) A series of surveys executed by national statistical offices throughout the European Union and in Norway and Iceland. The harmonized surveys are designed to give information on the innovation conducted by different sectors and regions. Data from these surveys is used for the annual European Innovation Scoreboard (EIS) and for academic research on innovation.

European Innovation Scoreboard (EIS) It has been published annually since 2001 to track, benchmark and provide a comparative assessment of the relative innovation performance of EU27 Member States. It has now been replaced by the Innovation Union Scoreboard (IUS).

Exports Percentage of total sales that corresponds to exports.

Extramural R&D expenses They include all the R&D expenditures spent outside of the statistical unit (outside of the firm).

High tech manufacturing industries (HT) Cutting edge technology industries. See table in Appendix A.3 for details on what fields are included in this classification.

Innovation Union Scoreboard (IUS) Formerly the European Innovation Scoreboard (EIS), it is meant to help monitor the implementation of the Europe 2020 Innovation Union flagship by providing a comparative assessment of the innovation performance of the EU27 Member States and the relative strengths and weaknesses of their research and innovation systems.

Intensity of innovation A relative measure of innovation expenses, such as total innovation expenses divided by the sales of the firm. In our case the variable RS measures the intensity of innovation, using both the R&D expenses and the total innovation expenses. See RS for more details.

Intramural R&D expenses All expenditures for research and development (R&D) performed within a statistical unit or sector of the economy during a specific period. Expenditures made outside the statistical unit or sector but in support of intramural R&D (e.g. purchase of supplies for R&D) are included. Both current and capital expenditures are included.

Knowledge Intensive Services (KIS) Services and business operations heavily reliant on professional knowledge. They are mainly concerned with providing knowledgeintensive support for the business processes of other organizations. See table in Appendix A.3 for details.

Low tech manufacturing industries (LT) Manufacturing industries that do not employ cutting edge technology. See table in Appendix A.3 for details on what fields are included in this classification.

Manufacturing, manufacturing industries Industries which involve in the manufacturing and processing of items and indulge in either creation of new commodities or in value addition. It does not include, for example, energy firms.

Market of firm Whether the firm operates in the national market, European Union or in other countries. These are all dummy variables and they are non-exclusive, meaning that a firm can answer "yes" to operating in all of those markets. Note that the dataset also included information on whether the firm operated in the local market (as it appears in the description of the data), but since the vast majority of the firms answered yes to this question, it was finally omitted as an explanatory variable from the analysis.

New firm Dummy variable that takes value one if the firm is less than two years old ("new") or zero otherwise.

Non Knowledge Intensive Services (NKIS) Services that are not knowledge intensive; see table in Appendix A.3 for details on the classification.

Output innovation (OI) Variable that measures the innovation succes of the firm. It is thought to be intrinsically unobservable, so it is measured using a proxy variable, which can be any of the following: percentage of total sales that come from a product new to the firm, percentage of total sales that come from a product new to the market, probability of a product innovation new to the firm, probability of a product innovation new to the market, or probability of a process innovation. The last three are dummy variables. Although the main results presented are obtained using the first one, Appendix A.1 discusses the results obtained using all measures.

Public funding Dummy variable that takes value one if the conducted innovation is paid in part using public funds, and zero if it does not.

R&D expenses Intramural R&D expenses plus extramural R&D expenses. A measure of technological innovation.

RD The R&D decision variable, indicates whether the firm has innovated (value one) or not (value zero). It can be measured in two ways: taking into account R&D expenses, in which case the variable is named RD (R&D); or taking into account total innovation expenses, in which case the variable is named RD (innov). Although the main results presented are obtained using the latter one, Appendix A.1 discusses the results obtained using both measures.

RS The innovation intensity (research size) variable. It measures the size or intensity of the innovation conducted by the firm, conditional on having innovated. Like the RD variable, It can be measured in two ways: taking into account R&D expenses, in which case the variable is named RS (R&D); or taking into account total innovation expenses, in which case the variable is named RS (innov). Although the main results presented are obtained using the latter one, Appendix A.1 discusses the results obtained using both measures.

Summary Innovation Index The main measure of the IUS and the EIS, that gives an "at a glance" overview of aggregate national innovation performance.

Technological Innovation Panel (PITEC) It is a statistical instrument that follows the technological innovation activities conducted by Spanish firms.

Total innovation expenses R&D expenses plus other innovation expenses, such as innovation on processes, etc.

Type of firm Whether the firm is public, private, or a research association. This information is included as dummy variables in the analysis. The dataset also included other categories under type of firm, like whether the firm was national or multinational (as seen in the description of the data), but this was not included in the final econometric analysis.

A.3 Classification of manufacturing and services

Subsector	NACE–93
High-tech manufacturing industries	
Chemical products (including pharmaceuticals)	24
Machinery and equipment	29
Office, accounting and computer machinery	30
Electrical machinery and apparatus	31
Radio, TV and communications equipment	32
Medical, precision and optical instruments	33
Motor vehicles	34
Naval, aeronautics and other transport equipment	35

Subsector	**NACE–93**
Low-tech manufacturing industries	
Food products and beverages	15
Tobacco	16
Textile industry	17
Clothing and furriers	18
Leather articles and footwear	19
Wood and cork	20
Paper industry	21
Graphic design and printing industry	22
Coke, refined petroleum products and nuclear fuel	23
Rubber and plastic products	25
Non metallic mineral products	26
Metallurgy industry steel products	271,272,273,2751,2752
Metallurgy industry non steel products	274,2753,2754
Metal products (save for machinery and equipment)	28
Furniture and other manufactures	36
Knowledge intensive services	
Telecommunications services	642
Financial intermediation	65,66,67
Real state activities	70
Software and other computer related activities	72
Research and development	73
Engineering and architecture technical services	742
Technical analysis	743
Recreactional, cultural and sporting activities	92
Other Services (Non-KIS)	
Wholesale trade	51
Retail trade	52
Catering industry	55
Transport	60,61,62
Travel agencies	63

Source: Personal compilation based on OECD, Eurostat and PITEC data.