Determinants of innovation output in Spanish knowledge-intensive service firms: Stability analysis throughout the economic crisis of 2008

Abstract

The aims of this paper are to identify the main determinants of the innovation output indicators (product, process, organization, marketing, products new to the firm, and products new to the market) of Spanish knowledge-intensive service (KIS) firms, to compare them with those of other categories of non-knowledge-intensive service (NoKIS) firms and manufacturing firms, and to analyze their evolution over the period 2004-2012, that is, immediately before and after the 2008 crisis. We used PITEC panel micro data, selecting and grouping firms into four categories according to their sector of activity and their intensity in use of technology and knowledge. The empirical results of our study confirm that the main determinants of innovation output are the following: cooperation with other partners to innovate, R&D intensity, and the size of the firm. These determinants are relevant not only for KIS firms but also for all the other categories. However, the influence of cooperation is more important for KIS firms for all of the innovation output indicators except for process innovation. Finally, with respect to the evolution of the main determinants over the period under study, the results show that they were not really affected by the crisis. Although all of the indicators for innovation output show clear influences of the economic cycle, the main determinants are not only the same, but their influence remains basically stable throughout the period.

Keywords: innovation; R&D; service sector; knowledge-intensive services; economic crisis impact; PITEC; Community Innovation Survey; Spain.

1. Introduction

In the economies of the most advanced countries in the world, including those of the European Union (EU), service activities have assumed a very significant importance, in terms of gross value added and employment, especially and increasingly those branches that make an intensive use of knowledge, and in which innovation plays a significant and competitive role.

The service sector as a whole accounted for 67,1% of the gross value added (GVA) and 64.0% of employment in the business economy of the EU-28 in 2016 (Eurostat, 2018) while service branches intensive in the use of knowledge represented 30.4% and 29.2%, respectively. The data relating to Spain show a distribution very similar to the EU-28.

In recent decades this growing importance has driven an abundant literature about the innovative activity of service firms (Gallouj & Savona, 2009), with different approaches evolving from a technologist or assimilation (in relation to manufacturing firms) to an integrative or synthesizing approach, in line with the trend towards convergence between the production of goods and services in a common conceptual framework. We will focus our analysis on knowledge-intensive services (KIS) firms, which according to various studies play an important role in innovation systems, becoming a category of special interest due to the positive externalities that generate, their competitive and global nature, and their role in productivity growth, placing technology-related KIS industries among the most innovative in the economy (Desmarchelier, Djellal, & Gallouj, 2013; Miles, 2005).

The latest revisions of the OECD's Oslo Manual (OECD-Eurostat, 2005) and the Community Innovation Survey (CIS), have given rise to a proliferation of empirical contributions on the relationship between R&D, innovation, and productivity, with an increasing presence of papers focused on the study of the determinants of innovative activities the service sector (Djellal, Gallouj, & Miles, 2013). However, most of them are of a cross-sectional nature or involve short periods of time, so do not provide information regarding the permanence or not of such determinants over time (Arvanitis, 2008; Barge-Gil & López, 2014; Segarra-Blasco, 2010). This question becomes more important especially if there are significant changes in the economic context of reference, as has occurred in most developed countries since 2008 with the advent of the so-called Great Recession, a global economic crisis that has affected their growth, and therefore the economic ecosystem in which firms from all sectors have had to develop their innovative activities.

Our study takes advantage of the availability of PITEC, the Innovation Technology Panel from the Spanish Foundation for Science and Technology (FECYT), which is considered to be the most complete database for observing the innovation activities of Spanish firms over time (Barge-Gil & López, 2014; Díez-Vial & Fernández-Olmos, 2017). It provides us with useful longitudinal information on the innovative activities of Spanish firms from 2004 to 2012 in two ways: first, the availability of 84,569 observations for 12,319 firms allows a very robust statistical analysis of determinants; second, nine years' of data that enable a quite detailed analysis of the evolution of determinants before and after 2008, in order to establish whether or not the crisis has had a significant impact on them.

The aim of this article is to question the persistence over time of the determinants of innovation output on Spanish KIS firms, measured through six indicators as dependent variables: four dichotomous related to product, process, organizational, and marketing innovation, and two continuous related to the ability to launch new products or services to the market successfully. Many of the most commonly used explanatory variables, such us R&D intensity firm size, market share, cooperation with other partners to innovate, belonging to a business group, use of public funds, export activity, human capital and the percentage of research employees, has been considered as potential determinants. While the focus of the study are KIS firms, it's interesting to compare their results with those of other three categories of firms: non-knowledge-intensive services (NoKIS), that groups service firms with a lower degree of use of knowledge and technology and two categories of manufacturing firms, high-technology (HTI) and medium-low-technology industries (LTI), in order to check to what extent the convergence in innovation activities between manufacturing and services is becoming a reality.

Although the main determinants of innovation output use to be similar for all categories of firms, according to the traditional literature, we expect that the wide sample available can allow us to identify possible differences and nuances between KIS firms and the rest of categories considered.

As for the assessment of extent to which the economic crisis of 2008 has affected the innovative activity of Spanish KIS firms, we expect changes related to the determinants of innovation output to be more likely in the intensity of their influence than in their very nature.

The results obtained are relevant to the specific literature about innovation in service firms, and in more general terms to the literature about the determinants of innovation, since there is a gap of studies about persistence or change in determinants over time based on large databases, even more of those covering the period around 2008 and intending to analyze the consequences of this economic crisis.

The rest of the article responds to the following structure: in Section 2, we describe the theoretical framework of innovation in the service sector; Section 3 presents the data used that comes from the PITEC panel; Section 4 details the analytical model used; and in Section 5 are shown the results obtained for the determinants of the six variables related to innovation output for all of the categories of firm defined and their evolution during the period in question in the case of KIS firms. Finally, Section 6 highlights the main findings and conclusions.

2. Theoretical framework: Innovation in the service sector

Traditionally, the literature on innovation was centered mainly on the manufacturing industry, considering service sectors as "laggards" in innovation processes and productivity growth, affected for the so-called "cost disease" (Baumol, 1967). Nevertheless, over the last two decades, and due to the growing importance of services in terms of wealth creation and employment, the study of innovation in the service sector has become a relevant topic.

Most recent literature (Djellal et al., 2013; Gallouj & Djellal, 2010; Gallouj & Savona, 2009) has assumed a specific framework to conceptualize the evolution of innovation in services, distinguishing three different approaches that in some way represent what can be considered the natural life cycle of theoretical concerns. First, the authors identify a technologist or assimilation approach, by far the oldest and with the highest number of contributions, whose main argument is that innovation in services can be reduced to the adoption and use of technology (mainly information and communication technologies—ICTs), considering the presence of non-technological innovation to be of little importance. The literature that adopts this approach tends to assimilate services within the consolidated framework used for manufacturing sectors and manufactured products, in comparison to which services have traditionally been considered "laggards". In one of the pioneering works, Gershuny and Miles (1983) raised the possibility that new technologies would change the cost and quality of services due to the "informational" component of most of them, thus giving way years later to the already widespread concept of knowledge-intensive business services (KIBS). However, the most important contribution is probably the work of Barras (1986), who proposed a conceptual framework with the introduction of what he called the "reverse product cycle (RPC) model" as a characteristic way to innovate in services, promoting a radical change in the hitherto dominant view in the literature whereby greater emphasis would be placed on non-technological innovation.

In one of the first attempts to formulate a general taxonomy of sectoral innovation trajectories, Pavitt (1984) identified four categories, classifying the whole services sector as "supplier dominated" firms. In subsequent developments a new category of "information-intensive" services was introduced (Pavitt, Robson, & Townsend, 1989). Trying to break down this simplified view, Soete and Miozzo (1989) rejected the hypothesis of considering services as a homogeneous sector and proposed a taxonomy that distinguished three types of firms: those dominated by suppliers of equipment and technical systems, who are not very innovative and simply purchase process technologies from their suppliers; network firms, characterized by a technological path based on cost reduction and the implementation of network strategies; and specialist science and technology providers, who are particularly active in technological innovations that often originate in their own R&D activities. More recent studies have distinguished four main categories of firm—"technology users," "science and technology-based services," "interactive services," and "technical consulting"—, with the most relevant features used for this classification being the innovative performance of firms, the underlying knowledge bases in different innovation processes, and the interaction patterns followed by firms to innovate (R. Evangelista & Savona, 1998, 2003).

In the mid-1990s, a new stream in the literature emerged, which is the service-oriented or differentiation approach (Drejer, 2004; Rinaldo Evangelista, 2006; Tether, 2005), which focused on identifying the specificities of innovation in service product and production processes, questioning to what extent the conceptual tools uses to analyze innovation activities in manufacturing sector are suitable in the service sector and tried to enlarge the perspective by giving more weight to non-technological aspects. The first contributions were empirical studies centered on knowledge-intensive business services (KIBS) and business services in general, which were followed later by more conceptual theoretical insights aimed at identifying sectoral-specific innovation behaviors (retail trade, financial services) (Barras, 1990; R. Evangelista & Savona, 2003), these insights enriching the perspective of innovation in services, but without intending to develop a general theory of innovation in services

Finally, due to the perception of the trend towards convergence and the blurring of boundaries between the production of goods and services, an integrative or synthesizing approach attempted to develop a common conceptual framework applicable to any tangible or intangible product, this approach being based on a new definition of product. The most important studies in this area share a functional vision of economic activity: a need—a function—can be satisfied by consuming a good or a service, so it is not necessary to distinguish between two types of “product”, this allowing an integrated analysis. After the pioneering work that proposed the notion of vector as a set of resources, and the necessary and sufficient conditions for the preparation and existence of a product (Belleflamme, Houard, & Michaux, 1989), together with that of those who identified three types of innovation applicable to both goods and services (Barcet, Bonamy, & Mayère, 1987), the functional perspective was especially developed by F. Gallouj. This author, through successive works written from both a qualitative and a quantitative (Gallouj, 2000, 2002b, 2002a; Gallouj & Savona, 2009; Gallouj & Weinstein, 1997; Sundbo & Gallouj, 2000), and based on the assumption that customers are interested in satisfying their needs (functions) regardless of whether it be with a product or a service, identified six modes of innovation in the service sector: radical, improvement, incremental, ad hoc, re-combinative, and formalization innovation.

Alongside this intense effort from a theoretical and typological point of view, there have been a large number of empirical contributions based on different surveys with firm-level data, which have been particularly interested in the study of the determinants of the innovative activities of service firms. Although in his compilation on the literature related to this aspect over the last five decades, Cohen (2010) refers mainly to manufacturing firms, he introduces a classification of determinants of innovative activities into three groups that can be considered also as reference for service sector firms: first, the classical determinants of Schumpeterian tradition, such as the size of the firm, and the structure of the market and its degree of concentration; second, those concerning the characteristics of the firm, such as the cash flow generated and the level of diversification or other capabilities directly related to R&D that influence its capacity for the absorption and assimilation of innovations; the third group is comprised of the determinants that identify specific characteristics of the manufacturing or service sector to which the firm belongs. The potential explanatory variables of the third group are organized under three main headings: the evolution of demand for the product or service, identified by the market’s size and growth dynamics; technological opportunity, largely identified by the sector of the firm, but also by other explanatory variables such as the various sources of information (internal, market, institutional, or tacit) used to innovate; and conditions of “appropriability” of the results of innovation, identified by the practice of patent registration, the use of secrecy, or the development of complementary capabilities in the areas of marketing or production.

Regarding the two Schumpeterian hypotheses, there is a broad consensus on the positive relationship between size and carrying out R&D (W. M. M. Cohen & Levin, 1989; Gilbert, 2006), with strong arguments to consider that the main cause is the advantages of size for the distribution of R&D costs and risks. Not so clear are the conclusions about the possible influence of the market structure. Although there is also a broad consensus on the importance of the specific characteristics of the sector, this consensus fails to clearly establish the direction and magnitude of their influence. The degree of knowledge of the role played by possible determinants directly related to the specific characteristics of the firm is even lower.

A sizeable number of studies have empirically addressed, in different geographical contexts, the analysis of the determinants of innovation in the services sector, comparing the results with those obtained in the manufacturing sector. Some references of this literature, without being exhaustive, are: Lööf (2005), that finds a consistent positive relationship between R&D, innovation and productivity for both samples, services and manufacturing, of Swedish firms; Cainelli, Evangelista, & Savona (2006), whose main results for Italian firms shows that innovation activities do have a positive impact on productivity levels and that better performing firms are more prone to innovate as well as to devote more resources to innovation; Mairesse & Robin (2010), that analyzing CIS data for French manufacturing and services firms over two periods, find a significant effect of product innovation and a little effect of process innovation on productivity; Segarra-Blasco (2010), that shows that labor productivity was directly affected by R&D intensity and product innovation in both services and manufacturing firms at regional level for Catalonia over the period 2002–2004; Masso & Vahter (2012), using CIS data for Estonia shows that innovation has a positive effect on productivity in the service sector, which is even stronger in the less knowledge-intensive firms and that non-technological innovations (marketing and organizational) play less important role than technological innovations (product and process).

Within the services sector, academics are devoting increasing interest to Knowledge-Intensive Services (KIS) firms, recognizing that "(they) are likely to play a major and positive role in the generation of economic growth in the long run" (Desmarchelier et al., 2013, p. 191), as "they can induce innovation among their clients" and, "despite a slow growth in the labor productivity, their demand is not heavily affected by the cost disease phenomenon. Nevertheless, the overall effect on economic growth remains unclear".

In the last decade, various empirical contributions, mainly focused in Knowledge Intensive Business Services (KIBS) firms, are deepening and enriching this debate with some interesting findings related, for example, to the fact that R&D might play a more important role in innovation of KIBS than is often assumed in the service innovation literature (Amara, Landry, & Doloreux, 2009); the recognition of the importance that external knowledge can have for innovation is not incompatible with the existence of firms that prefer to rely mainly on their internal capacities to innovate. (Doloreux, Shearmur, & Rodriguez, 2016); or that differences in innovation patterns among KIBS and manufacturing firms are more of degree rather than of kind (Freel, 2006). Some papers confirm that the presence of innovation and its extent has a consistently positive effect on growth, but no effect on productivity, with external linkages having an important positive effect on innovative firm performance (Mansury & Love, 2008).

Nevertheless, there are few contributions that analyze the determinants of innovation in KIS firms compared to those obtained for other service and manufacturing firms categories, and none that we know in the Spanish context. Moreover, the literature has not addressed the analysis of the temporal evolution of these determinants. Consequently, it confers additional interest to works that analyses the stability of determinants of innovation output over a quite long period of time, especially around the 2008 crisis, justifying the aims of our paper.

3. The data

In recent years, innovation surveys have been consolidated internationally using a common questionnaire about innovative activities in both manufacturing and service firms. These questionnaires are based on guidelines from different versions of the Oslo Manual, developed by the OECD (1992, 1996, 2005), whose third edition for the first time includes data about non-technological innovation and looks into the relationships between the different types of innovation. In Europe, the Community Innovation Survey (CIS) has been carried out biannually since 2004 by Eurostat (Eurostat, 2016a), who follow these guidelines and use the results as part of their statistics on science and technology.

In Spain, the National Institute of Statistics (INE) conducts the Spanish version of the CIS questionnaire annually. The statistics include firms with 10 or more employees from all the sectors, and provide information about the different types of innovation and other aspects of their development objectives, such as sources of information, innovation expenditure, the availability of public funds, and so on.

The access to and use of such data have traditionally presented two major problems: first of all, the need to maintain the anonymity of the participating firms' micro data, which is subject to statistical confidentiality; and secondly, the need for the precise treatment of the temporal evolution, especially when data from one year (e.g., innovation expenditures) have a delayed effect that will be reflected in subsequent years (e.g., increased sales of innovative products).

To address both problems, since 2004 the INE has been working in collaboration with the Spanish Foundation for Science and Technology (FECYT) and the Foundation for Technological Innovation (COTEC) to develop the PITEC Innovation Technology Panel (FECYT, 2015). PITEC is a data panel based on a representative selection of firms that makes it possible to carry out repeated observations of the economic units included over time and elaborate more precise estimations of the evolution of R&D&I activities in the business sector, determine the impact of innovation on productivity, and identify different strategies adopted by firms when introducing innovations into their business. The panel is made up of four non-excludable samples: (1) firms with 200 or more employees, (2) firms with internal R&D expenditures, (3) firms with fewer than 200 employees with external R&D expenditures but no internal R&D, and (4) firms with fewer than 200 employees with no innovation expenditures.

In the empirical analysis we use microdata from PITEC for the period 2004-2012, where firms have been selected and grouped, based on the NACE (Nomenclature of Economic Activities) code of their main economic activity, into four categories (Table 1): the first two, corresponding to service firms, have been classified according to the approach adopted by Eurostat (Eurostat, 2016b), depending on their intensity in the use of knowledge, thus distinguishing between those that use it (knowledge-intensive services—KIS), which account for as many as 3,389 firms, and those that do not (non-knowledge-intensive services—NoKIS), of which there are up to 1,806; the second two correspond to manufacturing firms, which are divided according to their technological level into high-tech (HTI), with up to 3,182 firms, and medium- and low-tech (LTI), with up to 3,942; the total sample is comprised of 12,319 firms (84,569 observations).

INSERT TABLE 1 ABOUT HERE

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4. Analytical model and methodology

4.1. Model

Most recent empirical studies on the topic of the relationship between innovation and productivity uses data from the CIS or another similar source (Hall, 2011). Up to 18 of them are based in the well-known CDM (Crepon, Duguet, & Mairesse, 1998) model or some of its variants for the analysis. According to the main goals and the context of this paper, we have selected a set of determinants among the more commonly used in those articles that includes services firms (Aboal & Garda, 2016; De Fuentes, Dutrenit, Santiago, & Gras, 2015; Freel, 2006; Griffith, Huergo, Mairesse, & Peters, 2006; Love, Roper, & Hewitt-Dundas, 2010; Mansury & Love, 2008), focusing particularly on the relationship between innovation inputs and outputs, which is what we analyses in our models.

In line with this empirical literature, we partially use a variant of the CDM model, specifically the innovation or knowledge equation, to evaluate the impact of R&D on various innovation output indicators. We measure the effect of knowledge through six different indicators, represented by two continuous variables related to product or service novelty, and four dichotomous variables related to technological (product and process) and non-technological (organizational and marketing) innovation. In general, the output innovation equation can be described as follows:

$$IO_i = \gamma r_i + \delta X_i + \vartheta_i \text{ (Equation 1)}$$

where r_i is the firm's R&D intensity, measured as the amount of R&D expenditure per employee, X_i is a vector with the remaining determinants of knowledge production, and ϑ_i is a random error term. With these estimations we are interested in determining the effect of R&D intensity on innovation output, but also in identifying other variables as potential determinants: the firm's size and market share, expressed as logs; a dummy that takes the value 1 when the firm makes cooperation agreements in innovation activities with other partners; a dummy that indicates whether or not the firm belongs to a group; a dummy that indicates whether or not the firm receives public funding for R&D and innovation; a dummy that indicates whether or not the firm exports; the human capital and research employee variables, that represent the percentage of graduates per total number of employees and the percentage of personnel (researchers and grant holders) involved full time in internal R&D carried out by the firm, respectively, expressed in log; finally, we include a vector with dummy variables for each year of the period, in order to reflect the evolution of indicators and determinants over the period.

4.2. Methodology

We organized our analysis in three consecutive stages. First, we searched for the main determinants of innovative behavior for KIS firms. The availability of a data source with panel structure, in which variables take values for the same sample units in all the years of the period 2004-2012, raised the possibility of using a specific analysis methodology. We used two different methods to test the predictions for our six variables: a random effect xtlogit model (because of the presence of time-invariant variables) to test the set of dichotomous dependent variables (product, process, organizational, and marketing innovation), and a fixed effect xtreg model (after rejecting the null hypothesis of the Hausman test) to test the set of continuous dependent variables (share of product new to the firm and to the market).

Secondly, once the main determinants had been identified, we compared the results of KIS firms to those obtained for the other three categories previously described (NoKIS, HTI, and LTI), with an interest in distinguishing possible different behaviors between them. To this end, we conducted a post-estimation test (lincom—linear combinations of parameters), which involved processing linear combinations of coefficients. Stata 12 lincom analysis gave us a confidence interval as well as a test of the null hypothesis where the difference between coefficients was zero. Running an interacted full model with a group variable (category) was previously necessary.

Finally, we focused on the analysis of the evolution of the three most important determinants, namely, cooperation, R&D intensity, and size, together with others whose results were significant. In this case, to capture variations of coefficients / marginal effects between years, we ran a regression analysis for each of the six indicators of innovation output described above and for every year (data pool by year). Complementary lincom analysis, using the time period as a control group, allowed us to confirm the relative values shown in Figures 1 to 6.

Classical econometric issues, namely, selectivity, simultaneity, and endogeneity problems were dealt with. Selectivity problems were solved by including both innovative and non-innovative firms in the analysis (Karlsson, Gråsjö, & Wixe, 2015). The xtlogit estimation under random effects allowed us to keep time-invariant variables. Thus, those firms which did not innovate in any period were considered in the models.

Previous studies mitigate many of the simultaneity and endogeneity problems by lagging explanatory variables (Barge-Gil & López, 2014; Costa-Campi, Duch-Brown, & García-Quevedo, 2014; Kunapatarawong & Martínez-Ros, 2016). However, PITEC poses questions that are related to a three-year time span. More specifically, PITEC defines the innovation output variables by taking into account innovations during the three-year period ending in the reference year. This hinders the inclusion of lagged explanatory variables in the model. However, we had a panel of firms, and consequently efficiency gains in the estimation were expected since it was possible to take differences between firms into account. A standard solution to simultaneity problems is the estimation of fixed-effect or random-effects models for panel data (Costa-Campi et al., 2014), and this is the approach that we used in the estimation of the models.

5. Results

In this section we summarize the results obtained from the innovation equations for the four sectoral categories of firm defined above (HTI, LTI, KIS, and NoKIS), and group them according to the following criteria: the firms' manufacturing or services nature and their technological intensity; the estimated differences between the KIS firms and the other categories of firm; and finally, the temporary stability of the coefficients of the determinants over time.

We analyze a set of innovation output indicators that was introduced in Equation 1. Two of the indicators are quantitative and measure the product innovation new to the firm, and the product innovation new to the market. The novelty of products in the market is close to the concept of radical innovation used in this paper, which involves innovative firms discovering new products or services. Both indicators provide quantitative information about product innovation, and this information can be interpreted as a measure of innovativeness.

Additionally, we use four dichotomous indicators of innovation output that correspond to the classical distinction between technological (product and process) and non-technological (organizational and marketing) innovation. The independent variables were chosen based on previous studies (Aboal & Garda, 2016; Crepon et al., 1998; Freel, 2006; Griffith et al., 2006; Huergo & Moreno, 2011; Love et al., 2010; Mansury & Love, 2008; Mongo, 2013; Segarra-Blasco, 2010). The independent variables are the following[1]: size of the firm, market share, group, cooperation, public funds, export, human capital, R&D intensity, and research employees.

PITEC data provides interesting information about all of the activities undertaken by firms in triennial periods, that is, the activities carried out during the year of reference and the two previous years. Regarding the data set used, the following comments need to be made: there are no data available to report on organizational and marketing innovation as dependent variables in 2006 and 2007; and there is a lack of data for the explanatory variables of human capital in 2004, and export in 2006 and 2007.

In Section 5.1, we present the main determinants of the innovation output of KIS firms. Then, in Section 5.2, we compare these results for KIS firms with those obtained for the other three categories previously described, in order to identify possible different behaviors between them. Finally, in Section 5.3, we focus on the analysis of the evolution of the more significant determinants across the time periods.

5.1. Determining factors of innovative behavior in KIS firms

Tables 2 to 5 present the results of panel logistic regression (xtlogit), taking product, process, organizational, and marketing innovation as dependent variables. Coefficients (Coeff) and odd ratios (OR) are reported for each of the sectoral categories (HTI, LTI, KIS, and NoKIS) previously defined. Table 6 to 7 shows us the results of fixed effects panel data regression for the continuous dependent variables, which are products that are new to the firm and those that are new to the market.

INSERT TABLE 2 TO 7 ABOUT HERE

These results show that the main determinants of the probability that KIS firms will innovate are their cooperative attitude, their size, and their R&D intensity. For all of the innovation output indicators, cooperation agreements are the most decisive factor, often much more so than the other factors. For instance, KIS firms with cooperation agreements with other partners to innovate multiply their probability of achieving product innovation by 5.2, by 3.7 in the case of process innovation, and by 2.5 and 2.3 in organizational and marketing innovation, respectively. Also, the elasticity to generate new product varies between 0.16 and 0.18, depending on whether it is for the firm or for the market.

In general, the second most important determinant is the intensity of R&D, which is also significant for all of the innovation output indicators, having a notable effect on the development of new products for the firm, which seems to be exclusively influenced by this and cooperation agreements. The marginal effect of R&D intensity is above 0.4 for product, process, and organizational innovation, and above 0.3 for marketing

1 Full description of variables is available at the end of the paper (Table 9 in Appendix)

innovation; whereas, in the case of size, the results are especially high for process and organizational innovation, with marginal effects of 0.84 and 0.97, respectively.

The third most important variable is the size of the company, which is also significant for all of the innovation output indicators except in the case of products that are new to the firm. Its relevance is remarkable, with it having almost the same weight as cooperation agreements in the cases of products that are new to the market and organizational innovation, and slightly less weight in process innovation. Consequently, radical innovations and internal changes in Spanish KIS firms, in both the productive and the organizational processes, seem to require the organization that carries them out to be of a certain size.

The rest of the determinants have a more diverse impact on the innovation output indicators. So, export activities and, to a lesser extent, human capital, have a moderate positive effect on all of the dichotomous indicators except process innovation. KIS firms that export increase their probability of achieving innovation in products by 42.3%, while the odds ratio with respect to human capital is 1.11. The availability of public funds has a slight positive influence on all of the dichotomous indicators except marketing innovation, and especially on process innovation, whose probability increases by 26.9% for firms who use them. Finally, it is interesting to note the influence of the presence of research personnel. The percentage of this kind of staff has a significant but negative influence on process and organization innovation, and a positive but scarcely relevant one on the share of sales of products or services that are new to the market, which indicates that radical innovations seem to require a certain overall company profile: a certain size, intensity of R&D, cooperation agreements, and a significant presence of research personnel.

5.2. Behavior of KIS firms compared to that of other categories

Once the main determinants of innovation in KIS firms have been identified, we are interested in knowing if these determinants behave in a different pattern in firms belonging to the other categories. We are interested in knowing if the impact of the determinants is significantly higher or lower in KIS firms compared to the impact in the other sectoral categories. The results of a post-estimation test (lincom) that was run on the coefficients shown in Tables 2 to 7 are presented summarily in Table 8 in graphic form[2].

INSERT TABLE 8 ABOUT HERE

Although a clearly defined general pattern cannot be extracted from the graph, certain remarkable behaviors are observed. Cooperation agreements have a special importance in KIS firms, this being significantly greater than that estimated for most of the other categories, and to a lesser extent in NoKIS firms, which seem to show a slightly different behavior of the service firms as a whole versus the manufacturing ones. R&D intensity also seems to play a relevant role in KIS firms, especially with respect to high-tech manufacturing firms, although less generally than cooperation agreements. Conversely, the presence of research employees has greater importance in the other categories compared to the KIS firms.

In a more detailed analysis, NoKIS firms have the same main determinants as KIS firms, with some differences in terms of the intensity of their effect, which include the following: cooperation presents higher

2 Full results of the analyses can be obtained from authors under request.

values in process innovation and lower values in marketing innovation; R&D intensity is relatively important for NoKIS firms, which present higher values in all of the innovation typologies; and size has lower values in process and organizational innovation.

Regarding other determinants with some significance, the percentage of graduates and, to a lesser extent, the availability of public funds are more important for NoKIS firms than for KIS firms in terms of obtaining better results in innovation output. The percentage of research employees represents a negative influence for both categories, although slightly less so for KIS firms.

In accordance with most empirical studies (Aboal & Garda, 2016; De Fuentes et al., 2015; Freel, 2006) and consistent with the integrative approach stream, that seeks to provide the same analytical framework for both goods and services, based on a new definition of product (Djellal et al., 2013), it is interesting to compare the behavior of KIS firms with that of manufacturing firms, both high- (HTI) and medium-low-technology (LTI). In general terms, it can be said that manufacturing firms have the same main determinants as KIS firms, although with some differences in intensity. So, regarding high-tech manufacturing firms, KIS has higher values for cooperation agreements and R&D intensity in most indicators. Size is more important for HTI firms than for KIS firms in product innovation, while it is less important than for KIS firms in marketing innovation. With respect to LTI firms, cooperation shows lower values than for KIS firms in all of the indicators, except in process innovation, and R&D intensity in organizational innovation; size presents higher values than for KIS firms in product and marketing innovation.

As for other determinants with a degree of significance, human capital is more important for KIS firms in product innovation, whereas it is more important for LTI firms in process innovation and for HTI firms in products that are new to the firm. Export and the availability of public funds do not exhibit significant patterns. Two things are remarkable: the difference in the influence of the number of research employees, with positive values being presented for manufacturing firms in all of the innovation indicators, while for KIS firms they are negative; and the relative importance of process innovation for LTI firms, for which higher values are presented than for KIS firms in most of the determinants.

In conclusion, all of the categories share the same main determinants, which are cooperation, R&D intensity, and size, although with differences in intensity. Cooperation is not only the most significant determinant for KIS firms but is also more important than for all the other categories in most indicators, which is especially relevant in comparison with the results of manufacturing firms (HTI and LTI), even in the case of product innovation. It is in organizational innovation that KIS firms obtain results higher than any other category in all of the main determinants.

5.3. Evolution of output innovation determinants for KIS firms during the period 2004-2012

In this third stage, we analyze the degree to which the main determinants of output innovation have remained stable throughout the period studied, including a few years of recession in the Spanish economy. This analysis addresses the problem of stability in the relationships found, which resembles the relevant problem of symmetry in physics, in our case symmetry over time (Rosen, 1995). It is a question of determining whether or not, at different moments in time, the determinants of innovation output, as well as their degree of influence, are the same, taking into account that we are considering periods in which the economic situation is substantially different: high growth vs. deep recession.

We focus our analysis on the evolution of the three main determinants and those which stand out from the rest in most years of the period under study. The coefficients of the yearly regression analyses are shown in Figures 1 to 6.

INSERT FIGURES 1 TO 6 ABOUT HERE

The coefficients of the dummy year (Tables 2 to 7) are included as a reference for innovation output, reflecting the evolution of the dependent variables. Complementary post-estimation lincom analysis, using the dummy year as a control group, allows us to confirm the relative values shown in Figures 1 to 6 and whether or not the differences between them are significant.

Regarding the behavior of the output innovation indicators, three different patterns can be seen: first, the one that groups those aligned with the business cycle, with some nuances in their growth up to and including 2010 but with a clear decline after this year, and includes the two technological typologies, together with the sales of novelty products (Figures 1, 2, 5 and 6); second, the constant downward trend shown for organizational innovation (Figure 3); and third, the singular case of marketing innovation, with a small but regular growth trend, especially in the final years of the period (Figure 4). Consequently, we could say that the economic cycle does not affect the innovative behaviors of firms equally, with the technological innovation indicators being more sensitive, probably because they imply a higher direct cost for firms (Audretsch & Elston, 2006; Martínez, Zouaghi, & García, 2017; Shaw, Duffy, Johnson, & Lockhart, 2005), while organizational innovation is less affected by the cycle and marketing innovation seems to show a certain countercyclical evolution.

With regard to the evolution of main determinants of output innovation, we can see how stay almost constant over time: the influence of cooperation presents small variations around general stability, with the sole exception of its growth trend for marketing innovation in the final years of the period. Cooperation also presents the highest values for all of the indicators in most years, with the exception of products that are new to the firm, where it is surpassed by R&D intensity. The latter determinant, as well as size, remain stable throughout the period with very small variations for all of the indicators.

The rest of the determinants only present statistically significant results in some of the years of the period, but there are some characteristics that can be highlighted. The percentage of researchers presents negative effects that remain constant in most years for process and organizational innovation, whereas it has positive ones for products that are new to the market that remain almost constant over all of the years of the period. The percentage of graduates has a slight positive effect on product, process, and organizational innovation, with similar low values in all of the years of the period that present statistically significant results. Finally, the availability of public funds shows negative effects in marketing innovation that remain constant over time.

Consequently, and especially for the main determinants, the relationships and influences found in the global analysis are maintained throughout the period analyzed, this showing the stability of these factors and their impact over time, regardless of the moment considered, whether it be one of economic growth or of deep recession. Although this result of stability might have been expected, its verification is important, especially considering the contingent influences of macroeconomic factors in many of the relationships in the social sciences (Luhmann, 1998), in company strategies (Porter, 1990), and especially in business innovation strategies (De Marchi, 2012; Segarra-Blasco, 2010).

6. Conclusions

The aims of this paper were to identify the main determinants of innovation for Spanish KIS firms, to compare these determinants with those corresponding to other service and manufacturing firms, and finally, to analyze their stability and evolution in the period before and after the Great Recession. As a data source we used PITEC, a panel that is based on the Spanish Innovation Survey and that covers the period 2004-2012, from which firms were selected and grouped into four categories, according to their sector of activity and their intensity in the use of technology and knowledge, with a total of 84,569 observations for 11,236 firms.

For our analysis, we worked with the innovation equation of the CDM model, in which the innovation output of firms is represented by six indicators, four corresponding to the classical distinction between technological (product and process) and non-technological (organizational and marketing) innovation, with the other two measuring the novelty of the product, expressed as the share in sales of products or services that are new to the firm, but not to the market, and of products and services that are new to the market.

As a first conclusion, we obtain robust results[3] for cooperation with other firms to innovate, R&D intensity, and size as the main determinants for all of the innovation typologies and for products that are new to the market, not only for KIS firms but also for all of the other categories, although in the case of the latter without such a well-defined pattern as in other studies (Griffith et al., 2006; Love et al., 2010; Segarra-Blasco, 2010). R&D intensity, a main innovation input indicator, has a positive influence on all of the innovation indicators for KIS firms. The expenditure in intramural, and external R&D per employee is also significant for all of the innovation typologies in all of the years and for share of sales of services that are new to the firm or to the market in several years, with a positive and quite stable influence throughout the period. The greatest weight among these expenditures corresponds to in-house R&D, defined as creative work undertaken by internal R&D staff to increase the stock of knowledge for developing new and improved products and processes. This in-house R&D includes the development of software, which undoubtedly plays a very important role in the innovation activity of KIS firms.

Second, cooperation emerges as the most important determinant of innovation output for Spanish KIS firms, with a stronger positive influence than in manufacturing firms for most indicators. Although some other studies have identified cooperation or some proxy (e.g., sources of information or external connectivity) as relevant determinants (Freel, 2006; Mansury & Love, 2008; Mongo, 2013), the robustness and persistence of the results over time could be considered a finding of this article. For KIS firms that cooperate, the probability of achieving technological innovations is around four times greater and more than double in the case of non-technological innovations. The literature suggests that cooperation with clients is more significant for services

3 See statistical indicators included in tables 2 to 7: Wald chi2, sigma, rho, r2, etc.

firms, which is consistent with their closer and more interactive relationship with the end user (Barcet, 2010). There should be further research in order to identify the most common typology of partners and which is the most valuable for Spanish KIS firms, taking advantage of PITEC, which provides qualitative information about different cooperation partners in innovation activities (e.g., other firms of the group, suppliers, clients or customers, consultants, and universities or public research institutes).

Third, there are no significant differences in the main determinants between firms of the four categories considered, with only some nuances in terms of the intensity of their effects. In services firms, depending on their knowledge intensity, NoKIS firms present higher values in process innovation and lower values in marketing innovation for cooperation agreements, whereas for R&D intensity present higher values in all of the innovation typologies; and for size show lower values in process and organizational innovation. A clear distinctive pattern cannot be identified, but the relative importance of R&D intensity for NoKIS firms is remarkable.

For their part, manufacturing firms, both high- (HTI) and medium-low-technology (LTI), also in general present the same main determinants as KIS firms. When comparing the two high-tech categories (KIS and HTI), it is noticeable that the first category presents higher values for all of the determinants in all of the indicators, apart from for the importance of size for HTI in product innovation. In the case of LTI firms, size has a greater influence on product and market innovation, whereas cooperation in general has a lesser influence apart from on process innovation. Of the other determinants, the availability of public funds and the number of graduates have a moderate positive effect on most indicators for NoKIS firms. There are no significant differences between the two high-tech categories, while what is noticeable is the importance of the availability of public funds in most innovation typologies, as well as the relevance of process innovation for LTI firms. These general statements are consistent with those found in most of the references cited in our study and are coherent with the perception of the growing convergence between the production of goods and services, which is behind the integrative approach to innovation in services. However, there is still a wide variety of sectoral behaviors that need to be further analyzed in future studies.

Special mention should be made of the percentage of research employees, defined in this article (see Table 9) as personnel (researchers and grant holders) involved full time in internal R&D carried out by the firm per total number of employees, which shows a negative and nearly constant effect in process and organizational innovation, whereas conversely it is clearly positive in the share of sales of new services, of those that are new to the firm in several years and especially those that are new to the market in all of the years of the period. These results may appear to be somewhat contradictory: while the percentage of research employees is not statistically significant for product innovation, it is positive for the share of sales of services that are new to the market. To the extent that the creation of new services appears to be more related to a radical innovation mode, it is coherent that a higher percentage of research personnel has a positive effect on this new product-service indicator, which is like what is found in manufacturing firms. Process or organizational innovation are more related to other modes of innovation in services (incremental, ad hoc, or formalization—see Section 2), where the involvement of as many personnel as possible could be more relevant than the number of full-time research employees in KIS firms. However, a doubt persists about a possible bias in the way that KIS firms account for internal R&D expenditures, as is suggested by the fact that their figures for these expenditures are much higher than those for the other typologies.

Finally, the results show that the crisis did not really affect the evolution of the main determinants over the period under study. Although all of the indicators of output innovation show clear influences of the economic cycle, following three different evolutionary patterns around 2008, the main determinants are not only the same, but their influence remains basically stable throughout the period, with the only exception being cooperation for marketing innovation, which exhibits a growth trend in the final years. The persistence of the determinants and their influence on Spanish KIS firms are relevant findings of this study, and are in line with those obtained in other studies of manufacturing firms (Huergo & Moreno, 2011).

The results obtained could be an interesting addition to the literature for several reasons: first, it is focused on a country (Spain) for which there is a gap in literature on this subject; second, it uses a huge Spanish data base (PITEC), allowing significant empirical results; third, it intends to analyses the consequences of the economic crisis of 2008 on KIS innovation output.

The empirical results allow consistent and reliable conclusions to be reached, but the nature and availability of the data source limits the scope and scale of these results, even though they are well suited to the aims of the present work. So, it would be desirable to repeat the study to cover a longer period after the crisis, thus considering the complete economic cycle to follow the evolution of the determinants over the entire post-crisis period.

It would also appear necessary to replicate the research in other contexts; we consider that the sample is large enough to reflect the variety of firms to be found in the Spanish business fabric, but there may be differences between Spain and other countries. Finally, it would be rewarding to carry out further research on the importance of cooperation with different partners.

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Appendix

INSERT TABLE 9 ABOUT HERE

Table 1. Classification of industry and service branches of activity by technological intensity and use of knowledge

Knowledge categories: grouped activities	Branches of activity NACE rev 1.1	 NACE rev 2
Knowledge-intensive services (KIS)		
Telecommunications	642	61
Computer programming, consultancy and related activities	722	62
Other information and communications services (Epigraphs 724 in NACE rev. 1.1 and 58 to 60 in NACE rev. 2, corresponding to publishing, audio-visual and broadcasting activities are grouped in PITEC within KIS, while not considered by Eurostat)	72 (exc.722), 921, 922	58, 59, 60, 63
Scientific research and development (R&D)	73	72
Financial and insurance activities (Activities defined by Eurostat as knowledge-intensive financial services)	65, 66, 67	64, 65, 66
Other professional and technical activities (Most of activities defined by Eurostat as knowledge-intensive market services - excluding financial intermediation and high-tech services)	74	69, 70, 71, 73, 74, 75
Education (Most of activities defined by Eurostat as other knowledge-intensive services)	80	85
Human health and social work activities (Most of activities defined by Eurostat as other knowledge-intensive services)	85, 90, 91, 92 (exc.921, 922), 93	86, 87, 88, 90, 91, 92, 93
Non-Knowledge-intensive services (NoKIS)		
Wholesale and retail trade, repair of motor vehicles and motorcycles	50, 51, 52	45, 46, 47
Transportation and storage	60, 61, 62, 63	49, 50, 51, 52, 53
Accommodation and food service activities	55	55, 56
High technology manufacturing industries (HTI)		
Chemicals and chemical products	24 (exc.244)	20
Pharmaceuticals	244	21
Machinery and equipment n.e.c.	29	28
Electrical equipment	31	27
Computer, electronic and optical products	30, 32, 33	26
Motor vehicles, trailers and semi-trailers	34	29
Building of ships and boats	351	301
Air and spacecraft machinery	353	303
Other transport equipment	35 (exc.351, 353)	30 (exc.301, 303)
Medium-Low technology manufacturing industries (LTI)		
Food products, beverages and tobacco	15.16	10, 11, 12
Textile	17	13
Wearing apparel	18	14
Leather and footwear	19	15
Wood and cork	20	16
Paper industries	21	17
Printing and reproduction of recorded media	22	18
Coke and refined petroleum products	23	19
Rubber and plastic products	25	22
Other non-metallic mineral products	26	23
Metallurgy	271, 272, 273, 274, 275	24
Fabricated metal products	28	25
Furniture	361	31
Other manufacturing	36 (exc.361)	32

Sources: OECD and Eurostat. NACE rev. 1.1 and rev. 2. PITEC

Table 2. Estimates from logistic regression of output innovation probability determinants, Product Innovation 2004-2012

	Product Innovation							
	Knowledge Intensive Service (KIS)		Non knowledge Intensive Service (NoKIS)		High Tech Industry (HTI)		Medium and Low Tech Industry (LTI)	
	Coeff.	OR	Coeff.	OR	Coeff.	OR	Coeff.	OR
R&D Intensity	0.486***	1.625***	0.636***	1.889***	0.390***	1.477***	0.454***	1.575***
	(0.0311)	*(0.0506)*	*(0.0527)*	*(0.0995)*	*(0.0330)*	*(0.0488)*	*(0.0264)*	*(0.0416)*
Size Firm	0.250***	1.284***	0.482***	1.619***	0.451***	1.570***	0.561***	1.752***
	(0.0753)	*(0.0966)*	*(0.166)*	*(0.269)*	*(0.124)*	*(0.194)*	*(0.106)*	*(0.185)*
Market Share	-0.0572	0.944	-0.558***	0.572***	0.311***	1.364***	0.134*	1.144*
	(0.0578)	*(0.0546)*	*(0.127)*	*(0.0729)*	*(0.0859)*	*(0.117)*	*(0.0705)*	*(0.0806)*
Cooperation = 1	1.646***	5.189***	1.764***	5.833***	1.014***	2.755***	1.074***	2.928***
	(0.0610)	*(0.316)*	*(0.122)*	*(0.709)*	*(0.0718)*	*(0.198)*	*(0.0622)*	*(0.182)*
Group = 1	0.132*	1.141*	0.158	1,171	-0.106	0.900	0.145*	1.156*
	(0.0775)	*(0.0885)*	*(0.139)*	*(0.163)*	*(0.0926)*	*(0.0833)*	*(0.0811)*	*(0.0938)*
Public Funds = 1	0.188***	1.207***	0.641***	1.898***	0.243***	1.275***	0.338***	1.403***
	(0.0638)	*(0.0770)*	*(0.130)*	*(0.247)*	*(0.0656)*	*(0.0836)*	*(0.0570)*	*(0.0799)*
Export = 1	0.353***	1.423***	0.500***	1.649***	0.367***	1.444***	0.332***	1.393***
	(0.0684)	*(0.0974)*	*(0.110)*	*(0.181)*	*(0.0760)*	*(0.110)*	*(0.0617)*	*(0.0859)*
Human Capital	0.106***	1.111***	0.209***	1.232***	0.00181	1,002	0.0619***	1.064***
	(0.0201)	*(0.0224)*	*(0.0366)*	*(0.0451)*	*(0.0270)*	*(0.0270)*	*(0.0227)*	*(0.0242)*
Research Employees	-0.0311	0.969	0.120	1,128	0.282***	1.325***	0.178***	1.194***
	(0.0383)	*(0.0371)*	*(0.0857)*	*(0.0967)*	*(0.0471)*	*(0.0624)*	*(0.0446)*	*(0.0533)*
Year = 2005	0.114	1,121	0.170	1,186	0.309***	1.362***	0.334***	1.396***
	(0.103)	*(0.116)*	*(0.163)*	*(0.193)*	*(0.109)*	*(0.148)*	*(0.0887)*	*(0.124)*
Year = 2006	0.121	1,128	0.310*	1.364*	0.704***	2.023***	0.648***	1.911***
	(0.111)	*(0.125)*	*(0.178)*	*(0.242)*	*(0.130)*	*(0.264)*	*(0.102)*	*(0.195)*
Year = 2007	0.0675	1,070	0.211	1,235	0.635***	1.887***	0.427***	1.533***
	(0.112)	*(0.120)*	*(0.181)*	*(0.223)*	*(0.132)*	*(0.249)*	*(0.103)*	*(0.158)*
Year = 2008	0.0641	1,066	0.160	1,174	0.623***	1.865***	0.407***	1.502***
	(0.110)	*(0.118)*	*(0.172)*	*(0.201)*	*(0.117)*	*(0.218)*	*(0.0929)*	*(0.140)*
Year = 2009	0.348***	1.416***	0.482***	1.620***	0.883***	2.418***	0.654***	1.924***
	(0.112)	*(0.158)*	*(0.172)*	*(0.278)*	*(0.122)*	*(0.296)*	*(0.0953)*	*(0.183)*

Year = 2010	0.440***	1.553***	0.650***	1.915***	1.145***	3.143***	0.785***	2.193***
	(0.113)	*(0.176)*	*(0.173)*	*(0.332)*	*(0.126)*	*(0.396)*	*(0.0977)*	*(0.214)*
Year = 2011	-0.583***	0.558***	-0.0607	0.941	-0.383***	0.682***	-0.493***	0.611***
	(0.115)	*(0.0641)*	*(0.178)*	*(0.168)*	*(0.122)*	*(0.0829)*	*(0.0993)*	*(0.0607)*
Year = 2012	-1.050***	0.350***	-0.482***	0.618***	-0.870***	0.419***	-0.886***	0.412***
	(0.117)	*(0.0411)*	*(0.185)*	*(0.114)*	*(0.125)*	*(0.0522)*	*(0.103)*	*(0.0425)*
Constant	-2.647***	0.0709***	-7.093***	0.000831***	-0.653	0.521	-2.457***	0.0857***
	(0.323)	*(0.0229)*	*(0.791)*	*(0.000657)*	*(0.476)*	*(0.248)*	*(0.381)*	*(0.0326)*
lnsig2u	1.622***	5.062***	1.965***	7.134***	1.705***	5.501***	1.822***	6.182***
	(0.0477)	*(0.241)*	*(0.0774)*	*(0.552)*	*(0.0520)*	*(0.286)*	*(0.0443)*	*(0.274)*
Observations	23,208		11,664		21,608		28,089	
Number of ident	3,389		1,806		3,182		3,942	
log likelihood	-10,513		-3,805		-8,782		-12,366	
Wald chi2 (18)	2,425		996.5		1,944		2,606	
Prob > chi2	0.000		0.000		0.000		0.000	
sigma u	2.250		2.671		2.345		2.486	
rho	0.606		0.684		0.626		0.653	
Likelihood-ratio test of rho=0	4,922		2,179		4,285		6,722	
Prob	0.000		0.000		0.000		0.000	

Source: PITEC

Note: Values represent coefficients (ME) and odds ratio of a logistic regression. R&D Intensity, size, market share, human capital and research employees are expressed in logs; cooperation, group, public funds and export are dummy variables; regression include a time dummy variable to identify year effects

Significance: *** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses

Table 3. Estimates from logistic regression of output innovation probability determinants, Process Innovation 2004-2012

	Process Innovation							
	Knowledge Intensive Service (KIS)		Non knowledge Intensive Service (NoKIS)		High Tech Industry (HTI)		Medium and Low Tech Industry (LTI)	
	Coeff.	OR	Coeff.	OR	Coeff.	OR	Coeff.	OR
R&D Intensity	0.419***	1.520***	0.747***	2.112***	0.282***	1.325***	0.406***	1.500***
	(0.0300)	*(0.0457)*	*(0.0531)*	*(0.112)*	*(0.0317)*	*(0.0420)*	*(0.0262)*	*(0.0393)*
Size Firm	0.837***	2.309***	0.490***	1.633***	0.901***	2.462***	0.913***	2.493***
	(0.0735)	*(0.170)*	*(0.151)*	*(0.247)*	*(0.123)*	*(0.303)*	*(0.0979)*	*(0.244)*
Market Share	-0.0210	0.979	-0.204*	0.815*	0.319***	1.375***	0.0362	1,037
	(0.0552)	*(0.0541)*	*(0.117)*	*(0.0957)*	*(0.0856)*	*(0.118)*	*(0.0648)*	*(0.0672)*
Cooperation = 1	1.307***	3.694***	2.315***	10.13***	1.179***	3.251***	1.475***	4.371***
	(0.0578)	*(0.213)*	*(0.126)*	*-1,274*	*(0.0655)*	*(0.213)*	*(0.0636)*	*(0.278)*
Group = 1	0.0929	1,097	0.404***	1.498***	0.0417	1,043	0.0331	1,034
	(0.0742)	*(0.0815)*	*(0.123)*	*(0.184)*	*(0.0878)*	*(0.0915)*	*(0.0771)*	*(0.0797)*
Public Funds = 1	0.238***	1.269***	0.564***	1.757***	0.0839	1,087	0.443***	1.557***
	(0.0618)	*(0.0783)*	*(0.122)*	*(0.214)*	*(0.0602)*	*(0.0654)*	*(0.0555)*	*(0.0864)*
Export = 1	0.0801	1,083	0.119	1,126	0.244***	1.276***	0.263***	1.301***
	(0.0637)	*(0.0690)*	*(0.0959)*	*(0.108)*	*(0.0714)*	*(0.0911)*	*(0.0581)*	*(0.0755)*
Human Capital	0.0165	1,017	0.0833***	1.087***	-0.0355	0.965	0.0814***	1.085***
	(0.0193)	*(0.0196)*	*(0.0312)*	*(0.0339)*	*(0.0256)*	*(0.0247)*	*(0.0213)*	*(0.0231)*
Research Employees	-0.210***	0.811***	-0.490***	0.613***	0.0204	1,021	-0.0689	0.933
	(0.0367)	*(0.0297)*	*(0.0838)*	*(0.0513)*	*(0.0444)*	*(0.0453)*	*(0.0438)*	*(0.0409)*
Year = 2005	0.386***	1.471***	0.519***	1.680***	0.308***	1.361***	0.345***	1.413***
	(0.0980)	*(0.144)*	*(0.139)*	*(0.234)*	*(0.101)*	*(0.138)*	*(0.0844)*	*(0.119)*
Year = 2006	0.475***	1.608***	0.657***	1.929***	0.742***	2.099***	0.742***	2.100***
	(0.106)	*(0.170)*	*(0.149)*	*(0.288)*	*(0.123)*	*(0.259)*	*(0.0964)*	*(0.202)*
Year = 2007	0.463***	1.588***	0.569***	1.767***	0.447***	1.564***	0.478***	1.613***
	(0.107)	*(0.170)*	*(0.150)*	*(0.265)*	*(0.125)*	*(0.195)*	*(0.0970)*	*(0.156)*
Year = 2008	0.649***	1.914***	0.565***	1.759***	0.484***	1.622***	0.505***	1.657***
	(0.105)	*(0.201)*	*(0.144)*	*(0.254)*	*(0.108)*	*(0.176)*	*(0.0886)*	*(0.147)*
Year = 2009	0.898***	2.455***	0.850***	2.339***	0.757***	2.132***	0.769***	2.157***
	(0.107)	*(0.262)*	*(0.146)*	*(0.342)*	*(0.112)*	*(0.240)*	*(0.0906)*	*(0.196)*

Year = 2010	0.904***	2.469***	1.139***	3.123***	0.894***	2.444***	0.896***	2.450***
	(0.108)	*(0.266)*	*(0.147)*	*(0.458)*	*(0.115)*	*(0.281)*	*(0.0931)*	*(0.228)*
Year = 2011	0.101	1,106	0.429***	1.536***	-0.348***	0.706***	-0.537***	0.585***
	(0.109)	*(0.121)*	*(0.149)*	*(0.229)*	*(0.114)*	*(0.0806)*	*(0.0930)*	*(0.0544)*
Year = 2012	-0.373***	0.688***	-0.0154	0.985	-0.851***	0.427***	-0.950***	0.387***
	(0.111)	*(0.0766)*	*(0.154)*	*(0.151)*	*(0.118)*	*(0.0503)*	*(0.0967)*	*(0.0374)*
Constant	-3.323***	0.0360***	-4.782***	0.00838***	-1.470***	0.230***	-2.653***	0.0704***
	(0.311)	*(0.0112)*	*(0.719)*	*(0.00603)*	*(0.473)*	*(0.109)*	*(0.351)*	*(0.0248)*
lnsig2u	1.611***	5.009***	1.959***	7.089***	1.821***	6.176***	1.606***	4.981***
	(0.0466)	*(0.233)*	*(0.0703)*	*(0.498)*	*(0.0490)*	*(0.303)*	*(0.0435)*	*(0.217)*
Observations	23,208		11,664		21,608		28,089	
Number of ident	3,389		1,806		3,182		3,942	
log likelihood	-11,528		-4,969		-10,284		-13,055	
Wald chi2 (18)	1,719		896		1,479		2,670	
Prob > chi2	0.000		0.000		0.000		0.000	
sigma u	2.238		2.663		2.485		2.232	
rho	0.604		0.683		0.652		0.602	
Likelihood-ratio test of rho=0	5,494		2,900		5,720		5,884	
Prob	0.000		0.000		0.000		0.000	

Source: PITEC

Note: Values represent coefficients (ME) and odds ratio of a logistic regression. R&D Intensity, size, market share, human capital and research employees are expressed in logs; cooperation, group, public funds and export are dummy variables; regression include a time dummy variable to identify year effects

Significance: *** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses

Table 4. Estimates from logistic regression of output innovation probability determinants, Organizational Innovation 2004-2012

	Organizational Innovation							
	Knowledge Intensive Service (KIS)		Non knowledge Intensive Service (NoKIS)		High Tech Industry (HTI)		Medium and Low Tech Industry (LTI)	
	Coeff.	OR	Coeff.	OR	Coeff.	OR	Coeff.	OR
R&D Intensity	0.453***	1.572***	0.579***	1.784***	0.276***	1.317***	0.374***	1.453***
	(0.0325)	*(0.0511)*	*(0.0491)*	*(0.0876)*	*(0.0338)*	*(0.0445)*	*(0.0266)*	*(0.0386)*
Size Firm	0.968***	2.632***	0.599***	1.820***	0.941***	2.562***	0.859***	2.361***
	(0.0736)	*(0.194)*	*(0.124)*	*(0.226)*	*(0.119)*	*(0.305)*	*(0.0934)*	*(0.221)*
Market Share	0.00618	1.006	-0.139	0.870	0.0945	1,099	-0.0235	0.977
	(0.0559)	*(0.0563)*	*(0.0969)*	*(0.0843)*	*(0.0832)*	*(0.0915)*	*(0.0619)*	*(0.0605)*
Cooperation = 1	0.915***	2.498***	0.904***	2.469***	0.875***	2.398***	0.642***	1.900***
	(0.0620)	*(0.155)*	*(0.110)*	*(0.273)*	*(0.0653)*	*(0.157)*	*(0.0593)*	*(0.113)*
Group = 1	-0.0762	0.927	0.538***	1.712***	0.0506	1,052	0.0121	1,012
	(0.0749)	*(0.0694)*	*(0.104)*	*(0.179)*	*(0.0855)*	*(0.0899)*	*(0.0734)*	*(0.0743)*
Public Funds = 1	0.126*	1.135*	0.423***	1.526***	0.128**	1.136**	0.150***	1.161***
	(0.0675)	*(0.0766)*	*(0.120)*	*(0.183)*	*(0.0630)*	*(0.0716)*	*(0.0566)*	*(0.0657)*
Export = 1	0.289***	1.336***	0.180**	1.197**	0.194***	1.214***	0.320***	1.378***
	(0.0662)	*(0.0884)*	*(0.0869)*	*(0.104)*	*(0.0742)*	*(0.0901)*	*(0.0606)*	*(0.0834)*
Human Capital	0.0602***	1.062***	0.154***	1.167***	0.0341	1,035	0.147***	1.159***
	(0.0211)	*(0.0224)*	*(0.0307)*	*(0.0358)*	*(0.0275)*	*(0.0284)*	*(0.0237)*	*(0.0274)*
Research Employees	-0.169***	0.845***	-0.208***	0.813***	0.183***	1.201***	0.0198	1.020
	(0.0395)	*(0.0333)*	*(0.0768)*	*(0.0624)*	*(0.0460)*	*(0.0553)*	*(0.0433)*	*(0.0441)*
Year = 2005	-0.341***	0.711***	-0.378***	0.685***	-0.259***	0.772***	-0.396***	0.673***
	(0.0963)	*(0.0685)*	*(0.117)*	*(0.0799)*	*(0.0985)*	*(0.0760)*	*(0.0802)*	*(0.0539)*
Year = 2006	-25.28	0.000	-24.86	0.000	-24.58	0.000	-24.88	0.000
	(1,210)	*(1.27e-08)*	*(2,518)*	*(4.02e-08)*	*(984.3)*	*(2.09e-08)*	*(1,411)*	*(2.22e-08)*
Year = 2007	-25.31	0.000	-24.90	0.000	-24.55	0.000	-24.82	0.000
	(1,224)	*(1.25e-08)*	*(2,524)*	*(3.87e-08)*	*(994.9)*	*(2.17e-08)*	*(1,428)*	*(2.37e-08)*
Year = 2008	-0.736***	0.479***	-0.481***	0.618***	-0.243**	0.784**	-0.386***	0.680***
	(0.105)	*(0.0500)*	*(0.123)*	*(0.0758)*	*(0.106)*	*(0.0829)*	*(0.0847)*	*(0.0576)*
Year = 2009	-0.781***	0.458***	-0.593***	0.553***	-0.315***	0.729***	-0.576***	0.562***
	(0.106)	*(0.0485)*	*(0.125)*	*(0.0689)*	*(0.109)*	*(0.0795)*	*(0.0868)*	*(0.0488)*

Year = 2010	-0.908***	0.403***	-0.701***	0.496***	-0.484***	0.616***	-0.660***	0.517***
	(0.107)	*(0.0433)*	*(0.127)*	*(0.0631)*	*(0.112)*	*(0.0690)*	*(0.0896)*	*(0.0463)*
Year = 2011	-0.954***	0.385***	-0.742***	0.476***	-0.510***	0.600***	-0.728***	0.483***
	(0.110)	*(0.0422)*	*(0.129)*	*(0.0612)*	*(0.114)*	*(0.0687)*	*(0.0918)*	*(0.0443)*
Year = 2012	-1.023***	0.359***	-0.714***	0.490***	-0.627***	0.534***	-0.737***	0.478***
	(0.111)	*(0.0400)*	*(0.131)*	*(0.0642)*	*(0.118)*	*(0.0628)*	*(0.0950)*	*(0.0454)*
Constant	-2.311***	0.0991***	-3.409***	0.0331***	-2.698***	0.0674***	-3.047***	0.0475***
	(0.315)	*(0.0312)*	*(0.593)*	*(0.0196)*	*(0.463)*	*(0.0312)*	*(0.337)*	*(0.0160)*
lnsig2u	1.272***	3.567***	1.181***	3.259***	1.433***	4.191***	1.279***	3.592***
	(0.0519)	*(0.185)*	*(0.0748)*	*(0.244)*	*(0.0533)*	*(0.223)*	*(0.0472)*	*(0.169)*
Observations	23,208		11,664		21,608		28,089	
Number of ident	3,389		1,806		3,182		3,942	
log likelihood	-9,275		-4,550		-8,512		-11,061	
Wald chi2 (18)	1,395		639.2		1,089		1,479	
Prob > chi2	0.000		0.000		0.000		0.000	
sigma u	1.889		1.805		2.047		1.895	
Rho	0.520		0.498		0.560		0.522	
Likelihood-ratio test of rho=0	2,841		1,247		3,080		3,469	
Prob	0.000		0.000		0.000		0.000	

Source: PITEC

Note: Values represent coefficients (ME) and odds ratio of a logistic regression. R&D Intensity, size, market share, human capital and research employees are expressed in logs; cooperation, group, public funds and export are dummy variables; regression include a time dummy variable to identify year effects

Significance: *** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses

Table 5. Estimates from logistic regression of output innovation probability determinants, Marketing Innovation 2004-2012

	Marketing Innovation							
	Knowledge Intensive Service (KIS)		Non knowledge Intensive Service (NoKIS)		High Tech Industry (HTI)		Medium and Low Tech Industry (LTI)	
	Coeff.	OR	Coeff.	OR	Coeff.	OR	Coeff.	OR
R&D Intensity	0.320***	1.378***	0.505***	1.657***	0.292***	1.339***	0.295***	1.343***
	(0.0356)	*(0.0491)*	*(0.0525)*	*(0.0870)*	*(0.0373)*	*(0.0499)*	*(0.0296)*	*(0.0397)*
Size Firm	0.586***	1.796***	0.706***	2.026***	0.178	1,195	0.818***	2.266***
	(0.0857)	*(0.154)*	*(0.147)*	*(0.299)*	*(0.126)*	*(0.151)*	*(0.106)*	*(0.241)*
Market Share	-0.0317	0.969	-0.255**	0.775**	0.148*	1.159*	-0.219***	0.803***
	(0.0654)	*(0.0633)*	*(0.114)*	*(0.0883)*	*(0.0892)*	*(0.103)*	*(0.0700)*	*(0.0563)*
Cooperation = 1	0.852***	2.343***	0.449***	1.567***	0.415***	1.514***	0.554***	1.739***
	(0.0682)	*(0.160)*	*(0.120)*	*(0.189)*	*(0.0669)*	*(0.101)*	*(0.0632)*	*(0.110)*
Group = 1	-0.0591	0.943	0.345***	1.412***	-0.327***	0.721***	-0.108	0.898
	(0.0872)	*(0.0822)*	*(0.122)*	*(0.173)*	*(0.0895)*	*(0.0645)*	*(0.0824)*	*(0.0740)*
Public Funds = 1	-0.0649	0.937	0.0723	1,075	0.00179	1,002	0.105*	1.111*
	(0.0753)	*(0.0706)*	*(0.130)*	*(0.140)*	*(0.0657)*	*(0.0658)*	*(0.0614)*	*(0.0682)*
Export = 1	0.282***	1.326***	0.477***	1.611***	0.392***	1.479***	0.428***	1.534***
	(0.0733)	*(0.0972)*	*(0.101)*	*(0.162)*	*(0.0798)*	*(0.118)*	*(0.0683)*	*(0.105)*
Human Capital	0.0595**	1.061**	0.154***	1.167***	0.0170	1,017	0.120***	1.128***
	(0.0246)	*(0.0261)*	*(0.0356)*	*(0.0416)*	*(0.0285)*	*(0.0290)*	*(0.0261)*	*(0.0295)*
Research Employees	0.0151	1,015	0.0362	1,037	0.193***	1.213***	0.257***	1.293***
	(0.0429)	*(0.0435)*	*(0.0816)*	*(0.0846)*	*(0.0489)*	*(0.0593)*	*(0.0472)*	*(0.0610)*
Year = 2005	-0.358***	0.699***	-0.413***	0.661***	-0.167	0.846	-0.281***	0.755***
	(0.115)	*(0.0805)*	*(0.143)*	*(0.0945)*	*(0.106)*	*(0.0898)*	*(0.0912)*	*(0.0689)*
Year = 2006	-28.37	0.000	-23.78	0.000	-23.01	1.01e-10	-32.14	0.000
	(19,054)	*(9.08e-09)*	*(3,478)*	*(1.64e-07)*	*(1,542)*	*(1.56e-07)*	*(114,764)*	*(1.26e-09)*
Year = 2007	-28.39	0.000	-23.75	0.000	-22.98	1.05e-10	-32.08	0.000
	(19,369)	*(9.09e-09)*	*(3,588)*	*(1.73e-07)*	*(1,550)*	*(1.63e-07)*	*(116,222)*	*(1.36e-09)*
Year = 2008	0.0833	1,087	-0.0168	0.983	0.429***	1.536***	0.292***	1.340***
	(0.122)	*(0.133)*	*(0.147)*	*(0.145)*	*(0.112)*	*(0.172)*	*(0.0950)*	*(0.127)*
Year = 2009	0.107	1,113	0.131	1,140	0.443***	1.558***	0.288***	1.333***
	(0.124)	*(0.138)*	*(0.148)*	*(0.168)*	*(0.115)*	*(0.179)*	*(0.0972)*	*(0.130)*

Year = 2010	0.162	1,176	0.00944	1,009	0.404***	1.497***	0.242**	1.274**
	(0.125)	*(0.147)*	*(0.151)*	*(0.153)*	*(0.118)*	*(0.177)*	*(0.100)*	*(0.127)*
Year = 2011	0.214*	1.238*	-0.0354	0.965	0.500***	1.649***	0.185*	1.203*
	(0.127)	*(0.158)*	*(0.153)*	*(0.148)*	*(0.120)*	*(0.198)*	*(0.103)*	*(0.123)*
Year = 2012	0.381***	1.464***	0.192	1,211	0.613***	1.845***	0.254**	1.290**
	(0.129)	*(0.189)*	*(0.154)*	*(0.187)*	*(0.123)*	*(0.228)*	*(0.106)*	*(0.136)*
Constant	-4.378***	0.0125***	-5.759***	0.00316***	-3.011***	0.0492***	-5.361***	0.00470***
	(0.369)	*(0.00463)*	*(0.708)*	*(0.00223)*	*(0.496)*	*(0.0244)*	*(0.386)*	*(0.00181)*
lnsig2u	1.564***	4.779***	1.431***	4.185***	1.487***	4.426***	1.508***	4.518***
	(0.0554)	*(0.265)*	*(0.0821)*	*(0.344)*	*(0.0556)*	*(0.246)*	*(0.0499)*	*(0.225)*
Observations	23,208		11,664		21,608		28,089	
Number of ident	3,389		1,806		3,182		3,942	
log likelihood	-7,694		-3,631		-7,920		-9,606	
Wald chi2 (18)	731.9		418.5		602		986.7	
Prob > chi2	0.000		0.000		0.000		0.000	
sigma u	2.186		2.046		2.104		2.126	
rho	0.592		0.560		0.574		0.579	
Likelihood-ratio test of rho=0	3,025		1,193		2,949		3,649	
Prob	0.000		0.000		0.000		0.000	

Source: PITEC

Note: Values represent coefficients (ME) and odds ratio of a logistic regression. R&D Intensity, size, market share, human capital and research employees are expressed in logs; cooperation, group, public funds and export are dummy variables; regression include a time dummy variable to identify year effects

Significance: *** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses

Table 6. Estimates from fixed effect data panel regression probability determinants, New Products to the Firm 2004-2012

	New product to the firm (% sales)							
	Knowledge Intensive Service (KIS)		No knowledge Intensive Service (NoKIS)		High Tech Industry (HTI)		Medium and Low Tech Industry (LTI)	
	Coeff.	ST.C.	Coeff.	ST.C.	Coeff.	ST.C.	Coeff.	ST.C.
R&D Intensity	1.150***	0.0822***	1.852***	0.132***	0.739**	0.0528**	1.260***	0.0900***
	(0.320)	*(0.0228)*	*(0.486)*	*(0.0347)*	*(0.343)*	*(0.0245)*	*(0.256)*	*(0.0183)*
Size Firm	0.636	0.0176	0.749	0.0207	4.356***	0.121***	2.841*	0.0787*
	(1.033)	*(0.0286)*	*(1.341)*	*(0.0371)*	*(1.678)*	*(0.0465)*	*(1.547)*	*(0.0429)*
Market Share	-0.767	-0.0272	0.515	0.0183	0.768	0.0272	1.115	0.0395
	(0.666)	*(0.0236)*	*(1.210)*	*(0.0429)*	*(1.120)*	*(0.0397)*	*(0.999)*	*(0.0354)*
Cooperation = 1	4.246***	0.164***	2.992**	0.116**	1.916***	0.0740***	1.434**	0.0553**
	(0.690)	*(0.0266)*	*(1.196)*	*(0.0462)*	*(0.703)*	*(0.0271)*	*(0.642)*	*(0.0248)*
Group = 1	1.275	0.0492	1.512	0.0584	-0.344	-0.0133	-0.759	-0.0293
	(1.001)	*(0.0386)*	*(0.951)*	*(0.0367)*	*(1.009)*	*(0.0389)*	*(1.007)*	*(0.0389)*
Public Funds = 1	0.0398	0.00154	0.900	0.0347	-0.117	-0.00450	0.309	0.0119
	(0.662)	*(0.0255)*	*(1.132)*	*(0.0437)*	*(0.582)*	*(0.0225)*	*(0.547)*	*(0.0211)*
Export = 1	0.390	0.0151	0.213	0.00822	1.019	0.0393	-0.502	-0.0194
	(0.582)	*(0.0225)*	*(0.674)*	*(0.0260)*	*(0.663)*	*(0.0256)*	*(0.501)*	*(0.0193)*
Human Capital	0.0619	0.00378	0.554***	0.0338***	0.507**	0.0309**	-0.133	-0.00812
	(0.167)	*(0.0102)*	*(0.204)*	*(0.0124)*	*(0.246)*	*(0.0150)*	*(0.191)*	*(0.0116)*
Research Employees	-0.00349	-0.000185	-1.594**	-0.0844**	0.809	0.0428	0.0430	0.00228
	(0.409)	*(0.0217)*	*(0.770)*	*(0.0408)*	*(0.493)*	*(0.0261)*	*(0.437)*	*(0.0231)*
Year = 2005	2.574***	0.0993***	0.510	0.0197	1.953**	0.0754**	3.952***	0.153***
	(0.711)	*(0.0274)*	*(0.650)*	*(0.0251)*	*(0.816)*	*(0.0315)*	*(0.637)*	*(0.0246)*
Year = 2006	1.711**	0.0660**	0.530	0.0205	1.632	0.0630	2.739***	0.106***
	(0.811)	*(0.0313)*	*(0.744)*	*(0.0287)*	*(1.043)*	*(0.0402)*	*(0.764)*	*(0.0295)*
Year = 2007	-0.493	-0.0190	-0.449	-0.0173	1.205	0.0465	2.017***	0.0778***
	(0.866)	*(0.0334)*	*(0.848)*	*(0.0327)*	*(1.081)*	*(0.0417)*	*(0.781)*	*(0.0301)*
Year = 2008	0.938	0.0362	-0.347	-0.0134	1.374	0.0530	3.815***	0.147***
	(0.885)	*(0.0342)*	*(0.849)*	*(0.0328)*	*(0.924)*	*(0.0357)*	*(0.723)*	*(0.0279)*
Year = 2009	1.033	0.0399	0.434	0.0167	2.009**	0.0775**	3.657***	0.141***
	(0.871)	*(0.0336)*	*(0.850)*	*(0.0328)*	*(0.988)*	*(0.0381)*	*(0.753)*	*(0.0291)*
Year = 2010	0.568	0.0219	0.943	0.0364	1.990**	0.0768**	4.936***	0.191***
	(0.872)	*(0.0337)*	*(0.870)*	*(0.0336)*	*(0.999)*	*(0.0386)*	*(0.793)*	*(0.0306)*

Year = 2011	-2.020**	-0.0780**	-1.323	-0.0511	-0.260	-0.0100	1.115	0.0430
	(0.880)	*(0.0340)*	*(0.837)*	*(0.0323)*	*(1.042)*	*(0.0402)*	*(0.801)*	*(0.0309)*
Year = 2012	-3.505***	-0.135***	-2.189**	-0.0845**	-2.186**	-0.0844**	-0.0955	-0.00369
	(0.916)	*(0.0354)*	*(0.890)*	*(0.0344)*	*(1.052)*	*(0.0406)*	*(0.825)*	*(0.0319)*
Constant	3.137	-0.116***	3.855	-0.218***	4.247	0.0251	6.288	-0.0924***
	(3.484)	*(0.0301)*	*(6.101)*	*(0.0405)*	*(5.576)*	*(0.0407)*	*(5.024)*	*(0.0327)*
Observations	23,208		11,664		21,608		28,089	
Number of ident	3,389		1,806		3,182		3,942	
R-sq Within	0.0185		0.0141		0.0109		0.0128	
R-sq Between	0.0644		0.0558		0.0265		0.0306	
R-sq Overall	0.0376		0.0364		0.0166		0.0199	
Corr(u_i, Xb)	0.0523		0.0561		-0.0721		-0.0124	
F test:	14		5		8,388		14	
Prob > F	0.000		0.000		0.000		0.000	
Sigma u	16.82		15.89		18.07		17.72	
Sigma e	19.77		15.25		20.75		20.43	
Rho	0.382		0.478		0.393		0.393	

Source: PITEC

Note: Values represent coefficients and standardized coefficients of a data panel regression. R&D Intensity, size, market share, human capital and research employees are expressed in logs; cooperation, group, public funds and export are dummy variables; regression include a time dummy variable to identify year effects

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

Table 7. Estimates from fixed effect data panel regression probability determinants, New Products to the Market 2004-2012

	New product to the market (% sales)							
	Knowledge Intensive Service (KIS)		No knowledge Intensive Service (NoKIS)		High Tech Industry (HTI)		Medium and Low Tech Industry (LTI)	
	Coeff.	ST. Cf.	Coeff.	ST. C.	Coeff.	ST. C.	Coeff.	ST. C.
R&D Intensity	0.541**	0.0458**	0.592*	0.0502*	0.634**	0.0537**	0.575***	0.0487***
	(0.268)	*(0.0227)*	*(0.338)*	*(0.0286)*	*(0.273)*	*(0.0232)*	*(0.204)*	*(0.0173)*
Size Firm	3.221***	0.106***	2.057*	0.0676*	2.314	0.0760	1.545	0.0507
	(0.924)	*(0.0303)*	*(1.091)*	*(0.0358)*	*(1.529)*	*(0.0502)*	*(1.043)*	*(0.0343)*
Market Share	0.0740	0.00311	-1.489	-0.0626	1.349	0.0567	-0.0932	-0.00392
	(0.649)	*(0.0273)*	*(1.037)*	*(0.0436)*	*(0.893)*	*(0.0375)*	*(0.751)*	*(0.0316)*
Cooperation = 1	3.887***	0.178***	2.603***	0.119***	1.738***	0.0795***	2.058***	0.0942***
	(0.616)	*(0.0282)*	*(0.899)*	*(0.0411)*	*(0.570)*	*(0.0261)*	*(0.500)*	*(0.0229)*
Group = 1	1.367	0.0626	0.0283	0.00129	0.553	0.0253	0.559	0.0256
	(0.839)	*(0.0384)*	*(0.650)*	*(0.0298)*	*(0.900)*	*(0.0412)*	*(0.773)*	*(0.0354)*
Public Funds = 1	0.654	0.0299	0.524	0.0240	0.890*	0.0407*	1.069**	0.0489**
	(0.619)	*(0.0283)*	*(0.935)*	*(0.0428)*	*(0.501)*	*(0.0230)*	*(0.415)*	*(0.0190)*
Export = 1	-0.153	-0.00702	1.075**	0.0492**	-0.150	-0.00686	-0.126	-0.00575
	(0.534)	*(0.0244)*	*(0.476)*	*(0.0218)*	*(0.562)*	*(0.0257)*	*(0.382)*	*(0.0175)*
Human Capital	0.171	0.0123	0.0653	0.00473	-0.128	-0.00928	0.153	0.0111
	(0.130)	*(0.00941)*	*(0.171)*	*(0.0123)*	*(0.186)*	*(0.0135)*	*(0.145)*	*(0.0105)*
Research Employees	1.433***	0.0900***	1.114*	0.0699*	1.323***	0.0831***	1.157***	0.0727***
	(0.379)	*(0.0238)*	*(0.658)*	*(0.0413)*	*(0.428)*	*(0.0269)*	*(0.360)*	*(0.0226)*
Year = 2005	1.064*	0.0487*	0.937**	0.0429**	3.223***	0.148***	2.482***	0.114***
	(0.630)	*(0.0288)*	*(0.452)*	*(0.0207)*	*(0.639)*	*(0.0293)*	*(0.459)*	*(0.0210)*
Year = 2006	1.589**	0.0727**	1.243***	0.0569***	3.012***	0.138***	2.557***	0.117***
	(0.675)	*(0.0309)*	*(0.469)*	*(0.0215)*	*(0.825)*	*(0.0377)*	*(0.554)*	*(0.0254)*
Year = 2007	1.420**	0.0650**	1.613***	0.0738***	3.077***	0.141***	2.946***	0.135***
	(0.724)	*(0.0332)*	*(0.496)*	*(0.0227)*	*(0.835)*	*(0.0382)*	*(0.570)*	*(0.0261)*
Year = 2008	1.312*	0.0601*	1.465***	0.0671***	4.438***	0.203***	3.359***	0.154***
	(0.711)	*(0.0326)*	*(0.501)*	*(0.0229)*	*(0.725)*	*(0.0332)*	*(0.523)*	*(0.0240)*
Year = 2009	1.729**	0.0792**	1.498***	0.0686***	4.265***	0.195***	3.653***	0.167***
	(0.728)	*(0.0333)*	*(0.530)*	*(0.0243)*	*(0.740)*	*(0.0339)*	*(0.549)*	*(0.0251)*
Year = 2010	1.409**	0.0645**	1.156**	0.0529**	5.012***	0.229***	3.563***	0.163***
	(0.718)	*(0.0329)*	*(0.530)*	*(0.0243)*	*(0.791)*	*(0.0362)*	*(0.559)*	*(0.0256)*

Year = 2011	-0.629	-0.0288	0.852	0.0390	3.249***	0.149***	1.596***	0.0731***
	(0.741)	*(0.0339)*	*(0.535)*	*(0.0245)*	*(0.808)*	*(0.0370)*	*(0.590)*	*(0.0270)*
Year = 2012	-1.880**	-0.0861**	0.327	0.0150	0.974	0.0446	0.898	0.0411
	(0.755)	*(0.0346)*	*(0.539)*	*(0.0247)*	*(0.798)*	*(0.0365)*	*(0.599)*	*(0.0274)*
Constant	-0.487	-0.0423	-8.618*	-0.293***	4.147	-0.125***	-1.188	-0.197***
	(3.251)	*(0.0304)*	*(5.228)*	*(0.0395)*	*(4.704)*	*(0.0394)*	*(3.589)*	*(0.0290)*
Observations	23,208		11,664		21,608		28,089	
Number of ident	3,389		1,806		3,182		3,942	
R-sq Within	0.0254		0.0163		0.0159		0.0164	
R-sq Between	0.125		0.189		0.0388		0.0792	
R-sq Overall	0.0789		0.0903		0.0273		0.041	
Corr(u_i, Xb)	0.102		0.185		-0.0424		0.0647	
F test:	16		3		12		14	
Prob > F	0.000		0.000		0.000		0.000	
Sigma u	16.47		12.95		16.44		13.45	
Sigma e	17.46		10.54		17.31		15.18	
Rho	0.432		0.561		0.435		0.403	

Source: PITEC

Note: Values represent coefficients and standardized coefficients of a data panel regression. R&D Intensity, size, market share, human capital and research employees are expressed in logs; cooperation, group, public funds and export are dummy variables; regression include a time dummy variable to identify year effects

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

Table 8. Comparison of regression coefficients of KIS firms versus HTI, LTI and NoKIS firms, 2004-2012

	Product Innovation			**Process Innovation**			**Organizational Innovation**			**Marketing Innovation**			**New Products to the Firm**			**New Products to the Market**		
Main determinants	HTI	LTI	No KIS	HTI	LTI	No KIS	HTI	LTI	No KIS	HTI	LTI	No KIS	HTI	LTI	No KIS	HTI	LTI	No KIS
Size	▨	▨				■			■	■	▨							
Cooperation	■	■			▨	▨		■		■	■	■	■	■		■	■	
R&D Intensity	■		▨	■		▨	■	■	▨			▨						
Other determinants																		
Public Funds		▨	▨	■	▨	▨			▨		▨							
Export					▨													
Human Capital	■	■	▨		▨	▨			▨			▨	▨		▨			
Research Employees	▨	▨		▨	▨	■	▨	▨		▨	▨				■			

Legend:

■ The determinant is more important for KIS firms

▨ The determinant is less important for KIS firms

□ Not statistically significant or not significant differences

Source: PITEC

Table 9. Variable definitions and descriptive statistics

Role in the equation	Variable name	Variable construction	Sample mean/ Standard dev.
Innovation output	Product innovation	Dummy variable, which takes the value 1 if the firm reports having introduced new or significantly improved products (new to the market or only to the firm) during the three-year period ending in the reference year	0.5210/0.4995
Innovation output	Process innovation	Dummy variable, which takes the value 1 if the firm reports having introduced new or significantly improved production processes during the three-year period ending in the reference year	0.5229/0.4994
Innovation output	Organizational innovation	Dummy variable, which takes the value 1 if the firm reports having introduced new or significantly amended forms of organization, business structures or practices, aimed at step changes in internal efficiency during the three-year period ending in the reference year	0.3359/0.4723
Innovation output	Marketing innovation	Dummy variable, which takes the value 1 if the firm reports having introduced the implementation of a new or significantly amended marketing concept or strategy that differs significantly from existing marketing methods during the three-year period ending in the reference year	0.2041/0.4030
Innovation output	New products to the firm	Share in sales of products or services new to the firm but not new to the market during the three-year period ending in the reference year	12.2410/25.9068
Innovation output	New products to the market	Share in sales of products or services new to the market during the three-year period ending in the reference year	8.9541/21.8454
Determinant of innovation	R&D intensity	R&D intramural and external expenditure in the reference year, per employee (in log)	2.0014/1.8512
Determinant of innovation	Size of the firm	Number of employees of the firm (in log)	1.7599/0.7174
Determinant of innovation	Market share	Firm's sales divided by the value of its industry's sales in the sample by NACE industry division group (Table 2) (in log)	-3.3302/0.9183
Determinant of innovation	Cooperation	Dummy variable, which takes the value 1 if the firm had some cooperative arrangements in innovation activities during the three-year period ending in the reference year	0.2785/0.4482
Determinant of innovation	Group	Dummy variable, which takes the value 1 if the firm belongs to a group of companies	0.3914/0.4880
Determinant of innovation	Public funds	Dummy variable, which takes the value 1 if the firm received EU, regional or local, funding for innovation projects during the three-year period ending in the reference year	0.3221/0.4672
Determinant of innovation	Export	Dummy variable, which takes the value 1 if the firm exports some of its sales in the reference year	0.4037/0.4906
Determinant of innovation	Human capital	Total of graduates divided per total employees (in log)	2.2418/1.5804
Determinant of innovation	Research employees	Personnel (researchers and grant holders) involved full time in internal R&D carried out by the firm divided per total employees (in log)	1.1377/1.3716