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Innovation drivers in Ecuadorian manufacturing

Los impulsores de la innovación en el sector manufacturero del Ecuador

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Os impulsionadores da inovação no setor manufatureiro do Equador

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Abstract

Purpose – The purpose of this paper is to study which are the drivers of different types of innovations for manufacturing firms. The considered innovation types are product, process, organizational and marketing innovations. In addition, this study also aims to understand why most types of innovation (with the exception of organizational innovation) have decreased over time.

Design/methodology/approach – The two non-overlapping waves of the Ecuadorian National Innovation Activities Survey 2013 and 2015 (NIAS) are used. To identify the determinants of the different types of innovations and to check whether the decisions to innovate are correlated, a tetravariate probit model is used.

Findings – The results obtained point to some relevant differences in terms of the drivers of the different types of innovation. In addition, it is also evident that with the passage of time, certain problems that may be reducing the incentives to innovate have become more acute.

Originality/value – The study adds new empirical evidence to the literature on the role of investments in incorporated technology in innovation in developing countries. In particular, for Ecuadorian firms, the

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acquisition of incorporated technology in capital goods seems to be very relevant. This highlights the existence of a supply-driven innovation strategy. However, there is also room for innovation strategies driven by demand conditions.

Keywords Innovation, Ecuadorian manufacturing, Drivers of innovation, Econometric modelling, Innovation types, Manufacturing

Paper type Research paper

Resumen

Objetivo – El propósito de esta investigación es estudiar cuáles son los impulsores de los diferentes tipos de innovaciones para las empresas manufactureras. Los tipos de innovación considerados son las innovaciones de producto, proceso, organizativas y de marketing. Además, este estudio también pretende comprender por qué la mayoría de los tipos de innovación (con la excepción de la innovación organizativa) han disminuido con el tiempo.

Diseño/metodología/aproximación – Se utilizan las dos olas de la Encuesta Nacional de Actividades de Innovación de Ecuador 2013 y 2015 (NIAS). Para identificar los determinantes de los diferentes tipos de innovaciones y para verificar si las decisiones de innovación están correlacionadas, se utiliza un modelo probit tetravariante.

Resultados – Los resultados obtenidos apuntan a algunas diferencias relevantes en términos de los impulsores de los diferentes tipos de innovación. Además, también es evidente que con el paso del tiempo ciertos problemas que pueden estar reduciendo los incentivos a innovar se han agudizado.

Originalidad/valor – El estudio agrega nueva evidencia empírica a la literatura sobre el papel de las inversiones en tecnología incorporada en la innovación en los países en desarrollo. En particular, para las empresas ecuatorianas la adquisición de tecnología incorporada en bienes de capital parece ser muy relevante. Esto pone de relieve la existencia de una estrategia de innovación basada en la oferta. Sin embargo, también hay espacio para estrategias de innovación impulsadas por las condiciones de la demanda.

Palabras clave – Impulsores de la innovación, Tipos de innovación, Sector manufacturero en Ecuador, Tipos de innovación, Fabricación

Tipo de artículo – Trabajo de investigación

Resumo

Objetivo – O objetivo desta pesquisa é estudar quais são os direcionadores de diferentes tipos de inovações para empresas de manufatura. Os tipos de inovação considerados são inovações de produto, processo, organização e marketing. Além disso, este estudo também visa entender por que a maioria dos tipos de inovação (com exceção da inovação organizacional) diminuiu com o tempo.

Design/metodologia/abordagem – São utilizadas as duas ondas da Pesquisa Nacional de Atividades de Inovação do Equador 2013 e 2015 (NIAS). Para identificar os determinantes dos diferentes tipos de inovações e verificar se as decisões de inovação estão correlacionadas, um modelo probit tetravariant é usado.

Resultados – Os resultados obtidos apontam para algumas diferenças relevantes em termos dos direcionadores dos diferentes tipos de inovação. Além disso, também é evidente que, com o passar do tempo, certos problemas que podem estar reduzindo os incentivos para inovar tornaram-se mais agudos.

Originalidade/valor – O estudo acrescenta novas evidências empíricas à literatura sobre o papel dos investimentos em tecnologia incorporada à inovação nos países em desenvolvimento. Em particular, para as empresas equatorianas, a aquisição de tecnologia incorporada em bens de capital parece ser muito relevante. Isso destaca a existência de uma estratégia de inovação baseada na oferta. No entanto, também há espaço para estratégias de inovação impulsionadas pelas condições de demanda.

Palavras-chave – Drivers de inovação, Tipos de inovação, Setor de manufatura no Equador, Tipos de inovaçã, Fabricação

Tipo de artigo – Trabalho de pesquisa

Introduction

Among 126 countries, according to the Global Innovation Index (Cornell University, INSEAD, and WIPO, 2018), Ecuador is in the 97th position. Having this in mind, our aims in this paper are threefold. First, we want to understand which are the drivers of innovation activities in Ecuadorian manufacturing firms. We consider in this paper a broad definition of innovation outputs that considers the four types in the Oslo Manual (OECD/Eurostat, 2005). Hence, we include product, process, organizational and marketing innovations. Second, we want to check whether the firms' decision to innovate is mainly driven by the same factors independently of the innovation type (as it happened, for instance, in Schmidt and Rammer, 2007, for German firms). Finally, since we detect in the data that there is less innovation of any type (with the exception of organizational innovation) in the second wave of the Ecuadorian innovation survey than in the first wave, we want to find out which are the innovation drivers that get worse from one period to the next in order to understand these time patterns for innovation in manufacturing firms.

To provide answers for our research questions, we use the currently available two non-overlapping waves of the Ecuadorian National Innovation Activities Survey 2013 and 2015 (NIAS). In order to identify the determinants of the different types of innovations and test whether the decisions to innovate are correlated among them, we estimate a tetravariate probit model.

Summarizing our main results in the paper as regards the three particular aims before mentioned, they are the following. First, as for the general drivers of innovation activities in Ecuadorian manufacturing firms, we obtain that several factors encourage innovation: good firms' demand conditions, better financial prospects and information on public support programs, competitive pressure, appropriability instruments with some information disclosure that facilitate spillovers, human capital, R&D effort (mainly on internal R&D), investment in capital goods, ICT related technologies and investments, and a minimum size of the firm (since firms with less than 50 employees are the less likely to innovate).

One relevant result from the paper about investments in innovation such as in R&D and in capital goods (machinery and equipment) is that for Ecuadorian firms there seems to be very relevant the acquisition of incorporated technology in capital goods. This highlights the relevance of a supply-driven innovation strategy for a developing country like Ecuador. Still, there is also room for demand-driven innovation strategies that obey to demand conditions, as uncovered by the relevance of performing (for instance) market research activities as drivers of innovation.

With respect to our second goal in the paper, we find some interesting differences in some drivers of innovation depending on the type of innovation. For instance, if in the market in which the firm operates there exists an unsatisfied demand or the necessity to reach quality improvements, this encourages product innovation. In addition, there exists self-selection based on productivity for process innovations. Furthermore, organizational innovation is the type of innovation that relies more on external R&D, and marketing innovation is the only one that seems to be unrelated to firms' size. Last but not least, ICT and related investments are relevant for process and marketing innovations, likely indicating that these technologies are either focused on digitalization of the firms' production processes or in online sales and e-commerce. As regards our third objective in the paper, the decrease in the propensities to innovate (excluding organizational innovation) from the first to the second wave of the survey, firms' perceptions about competition decrease, the use of appropriability instruments that avoid information disclosure (such as secrecy agreements) increases, and there is a reduction both in firms' investments such as R&D (specially internal) and also in software and hardware.

In view of the results obtained, we may extract some policy recommendations so that the decrease detected in the propensity to innovate among Ecuadorian manufacturing firms does not go any further. For instance, the public sector can promote a competitive environment for firms, encourage the use of IPRs as a means of appropriating innovations for the facilitation of spillovers, and analyze in depth what obstacles have increase for firms to reduce their effort in R&D (especially internal) and be less likely to invest in software and hardware.

Analytical framework on innovation strategies and sources of the innovative process

Firms' innovation strategies might be of a demand-driven type and/or of a supply-driven type. As highlighted in Frank *et al.* (2016) for Brazil, for a demand-driven strategy (market-oriented innovation) firms' investments in internal and external R&D are relevant, as well as the performance of market research activities. Therefore, innovation strategies driven by demand could be assimilated to innovative "make" strategies (Goedhuys and Veugelers, 2012), related more to the development of innovations within the firm. However, for the supply-driven strategy, which is based on technology-acquisition, what are relevant are firms' investments in fixed capital such as in machinery and equipment. This strategy is known as technology "buy".

As R&D private investment in Ecuador is still low, we wonder whether the acquisition of capital goods with incorporated technology is a strategy with more rewards in terms of innovation outputs than the one more based on R&D investments. As stated by Goedhuys and Veugelers (2012), as developing countries increase the level of development, it might happen that firms' investments in R&D that create new technology substitute the acquisition of already available technology. In the case of some countries in Latin America, it coexists a combination of innovation based in technology embedded in machinery (Navarro *et al.*, 2010) and low R&D effort (implying low firm's absorptive capacity and limited internal and technological capabilities, Cohen and Levinthal, 1989). This requires that innovation activities be broadly defined to include firms adopting existing technology (Dabla-Norris *et al.*, 2012). In this sense, innovation is the application in a firm of new knowledge that is not necessarily new for competitors, the market or the rest of the world (Goedhuys and Veugelers, 2012). Using a Schumpeterian perspective, this is defined as imitation more than as *de novo* innovation (Fagerberg *et al.*, 2010).

Another related branch of the literature about the drivers of technological change makes the distinction between demand-pull and technology push factors (Choi, 2018; Di Stefano *et al.*, 2012; Mowery and Rosenberg, 1979). When market demand promotes innovation, this is referred to as "demand-pull". However, when it is instead the development and supply of new technology what generates innovation, this is referred to as "technology-push". The demand-pull factors for technological progress are very narrowly related with the demand-driven firms' innovation strategies. Differently, technology-push factors are very much related with the technology supply that is made available for firms to benefit from incorporated technology through their acquisition of capital goods (supply-driven firms' innovation strategies). Both for demand-driven or demand-pull factors behind technological change, consumers and their needs are as important as the transfer of this information to firms. For developing countries, science and technology externally generated in more developed countries that is embodied in capital goods, such as machinery and equipment, can play a relevant role for innovation. As highlighted in Nemet (2009), the availability of exploitable "technological opportunities" can be very relevant for innovation. Furthermore, this might be dependent on the technological sector in which firms operate.

In this paper, to proxy for market-oriented innovation, we are going to consider, among others, investments in innovation inputs such as internal and external R&D and market research. For technology-acquisition innovation inputs, we consider the acquisition of capital goods with embodied technology (machinery and equipment).

Other inputs for innovation that can be useful independently of the strategy for innovation are those related to human capital (in which rests part of the absorptive capacity and specialized resources of a firm) and ICT investments. Furthermore, it is also relevant to account for other framework conditions like competition, access to finance and appropriability of innovation results. Finally, further controls in estimation will be included to account for firms' ownership, size and technological sector.

Types of innovation

The Oslo Manual (2005) considers product, process, organizational and marketing innovations. It defines product innovation as:

> [. . .] the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This includes significant improvements in technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics.

The definition of process innovation is "the implementation of a new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software". As for Marketing innovation, the definition is "the implementation of a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing". Finally, organizational innovation "is the implementation of a new organizational method in the firm's business practices, workplace organization or external relations".

Data, variables and descriptives

Data

We use the currently available two non-overlapping waves of the National Innovation Activities Survey 2013 and 2015 (NIAS) "Encuesta Nacional de Actividades de Innovación", which provides firm-level data information for the periods 2009-2011 and 2012-2014, respectively, for Ecuadorian firms. This is a survey sponsored by the Ecuadorian National Statistics and Census Office ("Instituto Nacional de Estadísticas y Censos", INEC), and the Secretary of Superior Education, Science, Technology and Innovation ("Secretaría de Educación Superior, Ciencia, Tecnología e Innovación", SENESCYT). The NIAS provides information about firms' characteristics related to innovation activities following the Frascati Manual and the Oslo Manual Guide of the OECD (OECD, 2002; OECD/Eurostat, 2005). The information in the survey is similar to the one in the community innovation surveys for European countries.

We extract the information from the survey corresponding to manufacturing firms and this gives us a working sample of 2,810 observations corresponding to 2,338 different firms. Of the total number of observations, 1,191 correspond to the first wave and 1,619 to the second wave. Only 472 firms have been included in two waves of the survey. The remaining 1,866 firms have only data in one wave (722 firms in wave one and 1,144 firms in wave two). In each wave, firms have been extracted from the population in the last Ecuadorian Economic Census (2010), which covers all regions in the country and is representative of industry-size strata. The survey excludes firms with less than 10 employees. Answering the questionnaire is compulsory for firms.

Explanatory variables

All explanatory variables in estimation are presented in this section (their definition is summarized in Appendix 1). We consider both firm-level regressors and regressors constructed at the industry-level. Since a year t wave of the survey provides the information on innovation output types covering a three-years period reaching period t, and the information on the survey for some variables is provided specifically for years t, $t-1$ and $t-2$, whenever is possible (to avoid simultaneity problems) we include the firm regressor lagged two periods. We do this for most of our firm-level regressors, although for some few the information in the survey is only provided for period t (e.g. the information on the firm belonging or not to a group or whether the company has foreign capital). For the construction of industry-level variables, there is only information available for period t. The specific timing information about each one of the regressors appears both in the summary table with variables definitions in Appendix 1 and in Tables I-III of estimation results in the Results section below.

Demand conditions. Among the variables to capture firms' demand conditions, we include four variables. The first one, *unsatisfied demand*, is constructed as the ratio of innovative firms in your sector-wave of the survey that declare as reason for performing activities directed to innovation, the detection of an unsatisfied demand in the product market. The second one, *quality improvement*, is more complex in construction. Firms separately rank the relevance of a group of objectives for developing innovation activities (from less relevant to more, that is from a value of 1 to a value of 4, since we recode these values in the opposite direction they appear in the survey). We calculate the mean value from 1 to 4 that a given firm gives to all the objectives in the group. Then, we calculate the ratio of the rank from 1 to 4 the firm gives to the specific objective of improving the quality of products (included in the group) over the previous calculated average for all objectives. With this, we have a measure of the *relative* importance for the firm of this particular objective for innovation. Next, to have a measure of the relative importance of this objective in general for the firm's sector and specific wave of the survey, we sum in a sector-wave all the calculated firms' ratios and normalize this measure by dividing by the total number of innovative firms in the particular sector-wave. The higher the value of this indicator, the higher the relative importance for a sector in a particular wave of the survey of the objective of improving the quality of products when pursuing innovation. The third variable, *d_market_research*, that accounts for the firm investing in market research or not, can point out some demand problems that require innovations. In Rodríguez-Moreno and Rochina-Barrachina (2019), the realization of market research activities by the firm is associated to a greater propensity to carry out R&D. We expect these three variables to encourage innovation. The fourth variable is a dummy variable that takes into account whether the company exports or not (*d_export*). The characteristics of demand in international markets might put pressure on firms' innovation incentives to match new and high quality and variety consumers' requirements, with a simultaneous exposure to international technology. However, if export markets are more competitive, exporters will face stronger competition. This second face of trade openness prevents sometimes from finding positive effects of exporting on innovation, since demand-side pressure for innovation could be countervailed by greater levels of competition in international markets (Goedhuys and Veugelers, 2012).

If demand conditions encourage innovation, this will give us some initial arguments in favor of firms using a demand-driven strategy in their innovative process.

Competition. Next, we focus on variables that can capture competition and market power. In this group, we include two types of variables. The first one, *threat of competition* and its square, has been calculated as the ratio of innovative firms in a sector-wave of the survey that declare performing activities directed to innovation due to the threat of competition. According to Arrow (1962) an increase in competition creates incentives for firms to innovate since the incremental profits from innovation are high (escape-competition effect).

Differently, according to Schumpeter (1943) enhanced competition reduces profits and future rents associated with innovation, so that firms have disincentives to innovate (Schumpeterian effect). Aghion *et al.* (2005) reconciled these two contradictory views by establishing a model that justifies an inverted-U shape relationship between competition and innovation. For us to capture the existence of an inverted-U shape relationship, we include not only our *threat of competition* variable but also its squared value. The second type of variable is *market share*, calculated as the ratio of the firm's sales over total sales of its sector in a particular wave. It is typically considered that firms with higher market shares face lower competition.

Financial conditions. Innovation activities have some features that make them likely to suffer from financial restrictions. For instance, they imply a higher associated risk as compared to other firms' activities. This is so as firms innovation activities are risky *per se*, as their outcomes are uncertain. This higher risk associated to these activities adds to firms' liquidity needs. Therefore, firms' financial restrictions might be crucial in determining their ability to innovate and, thus, those firms less financially constrained may enjoy an important comparative advantage. In fact, theoretical models predict a negative relationship between credit constraints and innovation, based on the existence of information asymmetries (Leland and Pyle, 1977) and lack of collaterals[1]. The problems that firms are likely to face when requesting credit for innovation, make them have a preference for internal financing for this type of investment (Hall, 2002; Hall and Lerner, 2010). We use in this paper two variables to measure the possibility of fewer internal financial restrictions. One of them, *relative productivity*, calculated as the ratio of the firm's (log) labor productivity to the sector-wave mean (log) labor productivity, might be behind the relative capacity of a given firm to generate cashflow. The other one, *d_group*, is a dummy variable indicating whether the firm belongs to a business group. Group-affiliation, by providing access to internal group resources, may partially replace an external capital market[2].

Finally, we include a variable on the firm's awareness about the existence of the following six innovation support instruments included in the survey: programs to improve quality and obtain certification, programs for workers training, innovation support programs, technical assistance programs for technology adoption and business management, entrepreneurship support programs, and export promotion programs. The variable *information on support programs* is constructed as the number of these public innovation support programs that the firm is aware off.

Appropriability. Firms can use legal instruments to protect their innovations. There are of different types (Levin *et al.*, 1987; Cohen *et al.*, 2000; Jensen and Webster, 2009; Arora and Gambardella, 2010), and we have grouped them in two variables. The first one, *safeguard*, has been constructed with information about intellectual property rights (IPRs). In particular, as the ratio of innovative firms in the firm's sector-wave of the survey that declare the use of trademarks, certificates of origin, copyrights, industrial designs, patents, or utility models to protect innovations. In the field literature, these protection mechanisms are considered formal methods for appropriability. The second one, *secrecy*, has been calculated as the ratio of innovative firms in the firm's sector-wave of the survey that declare the use of clauses or secrecy agreements with employees, suppliers or clients to protect innovations. The literature considers these mechanisms as informal methods for protection. It may happen that the first, *safeguard*, is indicative of appropriability of returns to innovation outputs that encourages firms to innovate. As one of the reasons for not using IPRs can be the associated disclosure of information (Duguet and Kabla, 2000), sectors were a high percentage of innovators use them may be indicative of protection of innovation dominating the threat of information disclosure. Beneito *et al.* (2014) found that patents have a positive effect on product innovation.

Differently, it could happen that the second, *secrecy*, is indicative of a sector concerned with the dissemination of information through the use of IPRs and, therefore, depends more on secrecy agreements to avoid the flow of ideas and spillovers. It is interesting to check whether this fact negatively affects the incentives to innovate of firms in the sector.

Nowadays more than ever firms face a tradeoff between protecting their returns from innovations, on the one side, and being able to disclosure enough information to be able to collaborate with others for innovation and to benefit from openness in the innovation process, on the other side. This tradeoff has been termed by Laursen and Salter (2014) as the paradox of openness. According to these authors, innovation in general requires openness (to absorb, learn and collaborate with external knowledge to the firm) but its commercialization requires some protection. The combination of both objectives inside the firm gives rise to particular firms' appropriability strategies. The paradox appears since to be increasingly open for innovation may also require more tools to be protected from being copied by competitors. However, simultaneously there may exist a tradeoff between appropriability and openness since a strong appropriability strategy may eliminate the possibility for the firm to be open for interaction with external sources of knowledge (Laursen and Salter, 2014).

It might happen that our *secrecy* variable captures low levels of firms' openness for innovation because of a high risk of imitation and/or a higher perception by the firm of that risk. In addition, the possibility of unwanted spillovers may prevent from openness (Cassiman and Veugelers, 2002). In the particular case of the Ecuadorian economy, where the use of patent rights is not very much extended among firms, it could happen that some firms use a strong protection through informal mechanisms (such as *secrecy*) to avoid so much knowledge disclosure that also prevents them from benefiting from open sources of knowledge (Liebeskind, 1997).

Human capital. We include here three dummy variables. The first one is a variable with value 1 when the firm has employees with tertiary education (*d_skill*). The second one is a variable with value 1 when the firm invests in workforce training. Finally, the third one is a variable with value 1 when the firm has workforce dedicated to engineering and industrial design. Better human capital is expected to be related to a higher ability to generate ideas and quality R&D projects and related investments.

Investments for innovation. First, we consider separately internal and external R&D intensities (over sales) as variables proxying for inputs of the innovative process related more to a market-oriented innovation strategy of the firm. *Internal R&D* refers to those R&D activities that are undertaken within the firm and *external R&D* to those R&D activities that are externally contracted by the firm to other firms or research institutions. According to Mowery (1983), conducting internal R&D activities is usually related to complex research projects requiring knowledge of a highly specialized, idiosyncratic variety, specific to a firm, or knowledge involving a high degree of coordination within the firm. On the other hand, conducting external R&D activities entails research projects that require more generic knowledge, applicable to a relatively wide range of industries and firms, and dealing with isolated or separable aspects of a firm's operations. In addition, firms may recourse to external R&D when they lack financial resources or their size is insufficient to face the sunk costs associated with opening and maintaining their own R&D lab.

The relationship between R&D and innovation was already surveyed by Griliches (1990), who reported a robust R&D-innovation relationship at the firm level.

Second, to check whether the two types of R&D investments are bound together by a relationship of complementarity or substitutability in their effects on the achievement of innovation outcomes, we further include the cross product of the internal and external R&D intensities. Beneito (2006) finds that contracted R&D does not produce significant innovations, as measured by patents, unless it is combined with in-house R&D. Cassiman and Veugelers (2006) obtain that the two investments are complementary in the achievement of innovations. Beneito *et al.* (2015) obtain that internal engagement in R&D activities is a condition *sine qua non* to accumulate knowledge and learning, whereas external R&D activities in isolation do not necessarily create such learning effects. Whether internal R&D helps external R&D, or vice versa, in the innovative success, will be an empirical matter that will be contrasted with the data. If external R&D needs internal R&D to get success, this is in line with the notion of absorptive capacity of Cohen and Levinthal (1990).

Finally, we consider in the group of variables on investments for innovation the variable *d_fixed_investment*, which is a dummy variable indicating whether the firm has invested in fixed capital. As stated in our Analytical Framework section above, firms can also follow a supply-driven innovation strategy that relies on the acquisition of technology incorporated in new machinery and equipment (capital goods).

ICT. We include three variables to account for the use of information and communication technologies. The first one is a dummy variable that takes into account whether the firm has a formal department of Information and Communication Technologies (*d_ICT*). The second one is a dummy variable taking value one when the firm invests in software (*d_software*). Finally, the third one is another dummy variable with value one when the firm invests in hardware (*d_hardware*). In particular, the arguments for ICT contributing to innovation are diverse. First, adds to firms' internal knowledge and enables firms to be better connected, to better manage information and to have access to external knowledge. Second, may affect innovation through more efficient organization of production or the supply of new and/or better products and services. In this sense, it may happen ICT use to be more orientated towards affecting business processes and work practices (e.g. just-in-time inventory management or electronic coordination with suppliers) and, hence, enabling cost reductions, or towards new services (or improved service speed), new ways of doing business, new ways of marketing (e.g. e-commerce) and greater customization.

Controls. Furthermore, we will also include in the vector of regressors some controls in estimation. The first one is the dummy variable *d_foreign*, which takes value 1 whenever the firm has foreign capital participation. The second one is the *log(age)* of the firm. Third, we include three dummy variables for firms' size groups (between 50 to 100 employees, from 100 to 200, and more than 200, being firms with less than 50 employees the reference category). Fourth, a time dummy for observations corresponding to the second wave of the survey (*d_time*). Fifth, dummies classifying firms' manufacturing sectors in *med-low tech*, *med-high tech*, and *high tech* (the reference category being *low tech*), following the OCDE classification as regards knowledge intensity. The purpose of this group of dummy variables is controlling for technological opportunities that could be related to the degree of technological content of the sectors to which firms belong. Finally, geographical dummy variables for Ecuadorian provinces are included.

Descriptives

In Table AII, we present descriptive statistics for all the variables involved in our analysis. For the sake of brevity, we do not include in Appendix 2 information on the provinces[3]. Product (present in 42 per cent of observations) and process innovations (48 per cent) are more common than organizational (25 per cent) and marketing innovations (27 per cent). Although 68 per cent observations have at least one innovation type, there are only 7 per cent of the observations corresponding to firms innovating in the four types of innovations.

In Table AIII, we present the mean values of the variables in our analysis for the four size groups that we control for in estimation. 63.41 per cent of observations correspond to firms with less than 50 employees. The rest of the distribution is quite similarly split among the other three size classes. One remarkable feature is that product, process and organizational innovations increase with firms' size. However, there is not a clear pattern as regards size for marketing innovations. Differently, larger firms invest more likely in fixed capital. In addition, they also perform more market research activities, are more likely to export, to belong to a business group and have foreign capital participation, are more aware of support programs for innovation, are more productive, older, are in sectors where there is more use of secrecy agreements and mainly property rights such as patents to protect innovation, are more likely to have skill workers, to invest in training and have engineers, to invest in ICT, software and hardware. All this said, however, firms with more than 200 employees are relatively more concentrated than other size categories in low tech manufacturing (66 per cent as regards around 54 per cent).

In Table AIV, we present the mean values of the variables in our analysis for the four technological sectors we control for in estimation. Med-high tech and high tech sectors perform more product and process innovations than low tech and med-low tech ones. For organizational and marketing innovations, only high tech sectors outperform all the others. As regards the rest of variables, there are differences between the aggregated group of med-high tech and high tech with respect to the aggregated group of low tech and med-low tech. These are that the aggregated more technological group has firms that more likely invest in fixed capital and perform market research, are more aware of support programs for innovation, are in sectors that use more often secrecy agreements and property rights to protect innovations, are more likely to have skill workers, to invest in training, to have engineers, to make more effort in investing in both external and mainly internal R&D, are more likely to use ICT, to invest in software and in hardware. In addition, the subgroup of high tech manufacturing has a size composition of firms relatively more orientated towards large firms than the other groups (31 per cent of observations for firms with more than 100 employees versus an average of 23 per cent of this type of observations for the rest of manufacturing sectors).

Finally, in Table AV we present the mean values of the variables in our analysis for the two differentiated waves in the survey. From 2011 to 2014, the percentage of innovators decreases in each innovation type, with the exception of organizational innovations (in which case the percentage increases from 22 per cent to 28 per cent). Pressure on sectoral unsatisfied demand decreases, the opposite happens for the pressure for quality improvement, firms are more likely to invest in fixed capital, the sectoral threat of competition decreases, firms are more likely to export, to belong to a group and have foreign capital participation, they are more aware of support programs to innovation, there is an increase in the sector's use of secrecy agreements and property rights to protect innovation, firms are more likely to have skilled workers and engineers, but they reduce the effort both in external and mainly internal R&D, they are more likely to use ICT, but they are not more likely to invest in software and hardware, there is a reduction in the percentage of firms below 50 employees (and an increase in all the other categories), and a slight increase in firms composition towards manufacturing sectors in med-high tech and high tech.

Results

We estimate a tetravariate *probit* model for the four discrete choices involved in the analysis. Let $y^*_{it,j}$ denote a latent variable underlying firm *i's* in wave *t* ($i = 1, \ldots, N$; $t = 2011, 2014$) propensity to perform innovation type *j* (*j*=product, process, organizational or marketing innovations) given firm and industry characteristics $x_{it-2\ or\ it}$[4]. The explanatory variables are the same for the four choices. Formally:

$$y^*_{it,j} = \beta'_j \cdot (x_{it-2\,or\,it}) + \varepsilon_{it,j}, \tag{1}$$

where β'_j captures the effects of explanatory variables on the propensity to perform innovation activity *j* and $\varepsilon_{it,j}$ denotes idiosyncratic errors that affect $y^*_{it,j}$. The observed dependent variables, $y_{it,j}$, corresponding to $y^*_{it,j}$ are defined as:

$$y_{it,j} = \mathbf{1}\left[y^*_{it,j} > 0\right], \tag{2}$$

where 1[ ] denotes the indicator function taking the value one if the condition between brackets is satisfied. Our model allows correlations among the four choices to be non-zero. This takes into account that firms' choices may possibly be interrelated. Estimation is performed with the Stata command *cmp* developed by Roodman (2011) that implements a pseudo-simulated maximum likelihood estimator. Correlation coefficients for the error terms associated to the four choices are shown at the bottom of Tables I-III. All of them are positive and significant.

By following the same grouping of explanatory variables than in the Data, Variables and Descriptives section above, we start by commenting results in Table I on the variables capturing firms' demand conditions. For the variable *d_market_research*, coefficients are positive and significant for the four innovation types. This indicates that demand concerns encourage in general firms' innovation. However, when in the sector in which the firm operates is detected an *unsatisfied demand* or it is very relevant the *quality improvement* of products, this specially favors the firm's incentives to introduce product innovations. In addition, we do not confirm that the potentially larger market size faced by exporters encourages innovation, since they also likely face fiercer competition in international markets, what discourages them to perform process and marketing innovations (very likely, the high levels of competition in those markets make the Schumpeterian effect on innovation to prevail).

Second, as regards variables more specifically related to competition, when there is a perceived *threat of competition* in the sector we obtain an inverted-U shape relationship between competition and innovation for process and marketing innovations (first, dominates the escape-competition effect and, later, acts the Schumpeterian discouraging effect), a linear positive effect for product innovation (escape-competition effect) and no relationship for organizational innovation. In addition, the variable market share is most of the times non-significant.

Third, considering now financial conditions, firms belonging to a business group are better prepared to introduce product, organizational and marketing innovations. Furthermore, firms with higher capacity to create cashflow (as measured by their relative productivity) have more incentives to introduce process innovations. In addition, the more information a firm has on potential support programs for innovation the higher the likelihood of whatever innovation type. These results line up with the ones obtained for financial constraints by Goedhuys and Veugelers (2012), who uncover that financial constraints are a significant barrier to the innovation process.

Table I. Estimation results from the tetravariate probit model for the firms' innovation choices

Variables	(1) Product *dy/dx* (Aver. Marg. Eff.)	(2) Process *dy/dx* (Aver. Marg. Eff.)	(3) Organizational *dy/dx* (Aver. Marg. Eff.)	(4) Marketing *dy/dx* (Aver. Marg. Eff.)
Demand conditions				
Unsatisfied demand	0.00193*** (0.000576)	0.000414 (0.000574)	−0.000152 (0.000516)	0.000677 (0.000548)
Quality improvement	0.154** (0.0730)	−0.0601 (0.0688)	0.0180 (0.0672)	0.0673 (0.0752)
*d*_Market research $t-2$	0.244*** (0.0529)	0.0898* (0.0500)	0.125*** (0.0362)	0.169*** (0.0368)
*d*_export $t-2$	−0.0363 (0.0256)	−0.0576** (0.0250)	0.00662 (0.0230)	−0.0557** (0.0248)
Competition and market power				
Threat of competition	0.00411*** (0.00144)	0.0155* (0.00797)	−0.00113 (0.00728)	0.0120⸸⸸ (0.00838)
Threat of competition^2	–	−0.000177* (9.85e − 05)	−8.58e − 06 (9.12e − 05)	−0.000166‡‡‡ (0.000103)
Market share $t-2$	0.118 (0.139)	0.105 (0.137)	0.162 (0.113)	−0.273* (0.158)
Financial conditions				
*d*_group	0.0401† (0.0252)	0.0152 (0.0254)	0.0385* (0.0224)	0.0570** (0.0240)
Inf. support programs	0.0192*** (0.00534)	0.0243*** (0.00519)	0.0263*** (0.00469)	0.0295*** (0.00489)
Relative productiv. $t-2$	−0.0516 (0.0525)	0.0780⸸ (0.0518)	0.0607 (0.0489)	0.00888 (0.0491)
Appropriability				
Secrecy	−0.00362 (0.00239)	−0.00404‡‡ (0.00249)	−0.00179 (0.00221)	−0.00660*** (0.00251)
Safeguard	0.00425** (0.00187)	−0.000491 (0.00183)	0.000454 (0.00166)	0.00623*** (0.00180)
Human capital				
*d*_skill	0.0684** (0.0271)	0.0750*** (0.0272)	0.0559** (0.0268)	0.0348 (0.0267)
*d*_training $t-2$	0.185*** (0.0279)	0.195*** (0.0286)	0.0694*** (0.0237)	0.0806*** (0.0251)
*d*_engineers	0.0571** (0.0227)	0.0652*** (0.0225)	0.0764*** (0.0200)	0.0525** (0.0212)
Investments for innovation				
Internal R&D $t-2$	0.0165‡ (0.0104)	0.0291*** (0.0111)	0.00532 (0.00419)	0.00156* (0.000922)
External R&D $t-2$	0.0449* (0.0248)	0.0157 (0.0254)	0.0403* (0.0234)	0.00836 (0.0157)
Internal*External R&D $t-2$	−0.00489 (0.00353)	0.0238** (0.0114)	0.0112 (0.00821)	0.00329 (0.00345)
*d*_fixed investment $t-2$	0.151*** (0.0179)	0.200*** (0.0165)	0.0674*** (0.0169)	0.0514*** (0.0176)

(*continued*)

Table I.

Variables	(1) Product *dy/dx* (Aver. Marg. Eff.)	(2) Process *dy/dx* (Aver. Marg. Eff.)	(3) Organizational *dy/dx* (Aver. Marg. Eff.)	(4) Marketing *dy/dx* (Aver. Marg. Eff.)
ICT				
*d*_ICT	0.0290 (0.0247)	0.0688*** (0.0242)	0.0247 (0.0215)	0.0375‡‡ (0.0231)
*d*_software $t-2$	0.00597 (0.0406)	0.156*** (0.0472)	0.0397 (0.0333)	0.0975*** (0.0345)
*d*_hardware $t-2$	0.0236 (0.0366)	0.172*** (0.0428)	0.0275 (0.0308)	0.0201 (0.0326)
Controls				
*d*_foreign	0.0329 (0.0334)	−0.0112 (0.0329)	−0.0138 (0.0294)	−0.103*** (0.0326)
Log age	−0.00247 (0.0118)	−0.0228* (0.0116)	−0.0266** (0.0108)	−0.0171⸸ (0.0113)
Size2 (> = 50,<100) $t-2$	0.0519* (0.0268)	0.00900 (0.0271)	0.0350†† (0.0238)	0.0122 (0.0255)
Size3 (> = 100,<200) $t-2$	0.0266 (0.0324)	0.0575* (0.0326)	−0.0103 (0.0294)	−0.00744 (0.0314)
Size4 (> = 200) $t-2$	0.0643* (0.0375)	0.0825** (0.0355)	−0.00675 (0.0320)	−0.0179 (0.0355)
*d*_time	−0.0891*** (0.0184)	−0.0632*** (0.0184)	0.0304* (0.0172)	−0.0410** (0.0177)
Med-Low tech manufacturing	0.0691*** (0.0243)	−0.0274 (0.0244)	−0.0134 (0.0218)	−0.0206 (0.0231)
Med-High tech manufacturing	0.117*** (0.0291)	−0.000235 (0.0293)	−0.0243 (0.0268)	−0.0119 (0.0282)
High tech manufacturing	0.0700 (0.0586)	0.0754 (0.0579)	0.0232 (0.0497)	0.0275 (0.0537)
Observations	2,810	2,810	2,810	2,810
Log pseudo-likelihood	−57,43.1335			
Correlation coefficients	$\rho_{12} = 0.571$, p-value = 0.000; $\rho_{13} = 0.224$, p-value = 0.000; $\rho_{14} = 0.269$, p-value = 0.000; $\rho_{23} = 0.265$, p-value = 0.000; $\rho_{24} = 0.246$, p-value = 0.000; $\rho_{34} = 0.360$, p-value = 0.000			

Notes: Robust standard errors in parenthesis; ***$p < 0.01$; **$p < 0.05$; *$p < 0.1$; †p-value = 0.112; ‡p-value = 0.110; ⸸p-value = 0.132; ‡‡p-value = 0.105; ††p-value = 0.142; ††p-value = 0.152; ‡‡‡p-value = 0.109; dy/dx for dummy variables is the discrete change from the 0 to the 1 category; we have included in estimation provinces fixed effects

Fourth, appropriability conditions. We confirm that in sectors that protect their innovations mainly through the use of IPRs (variable *safeguard*) the effects on innovation, when statistically significant, are positive (this happens for product and marketing innovations). This may signal that in those sectors there is no high fear of information disclosure through patenting, etc., what may facilitate the existence of between firms' spillovers. Differently, in those sectors that rely more in protecting innovations through the use of secrecy agreements (variable *secrecy*), it may happen that minimizing the possibility of knowledge spillovers between firms reduces innovation incentives. We corroborate this idea in estimation since when the variable *secrecy* is statistically significant its effect on innovation is negative (this happen for process and marketing innovations).

Fifth, as for the human capital variables, we obtain that all of them are positive and statistically significant for the four types of innovations (with the only exception of the dummy for the use of skill-labor in the marketing equation, where although positive is non-significant). The group of dummy variables for measuring the firm's human capital is *d_skill*, *d_training* and *d_engineers*.

Sixth, as for the variables capturing investments in innovation, both internal and external R&D investments are relevant for product innovation. Furthermore, for process innovation, what emerges as more relevant is internal R&D, and external R&D is only relevant when combined with internal. For organizational and marketing innovations, we obtain opposite results. Organizational innovation seems to be facilitated by external R&D and, differently, marketing innovation by internal R&D. Differently to Frank *et al.* (2016) for Brazil, we find that externally contracted R&D is relevant for three out of the four innovation outputs considered, either with an independent role on innovation or in combination with R&D internal knowledge. Furthermore, *d_fixed_investment*, the variable that proxies for a supply-driven innovation strategy, has a positive and highly statistically significant coefficient for the four innovation types. The relevant in magnitude and very clear results obtained for the variable capturing investment in capital goods might be indicative of an important and fruitful input for innovation in the case of Ecuadorian firms. This result is different to the one obtained in Frank *et al.* (2016) for Brazil using 34 industrial sectors at an aggregate level, since they hypothesize that for Brazilian firms investments in technology acquisition are more oriented towards upgrading outdated technology. Typically, the lack of rewards in terms of innovation outputs of an innovation strategy based on technology acquisition relies for developing countries in deficiencies in firms' absorptive capacity. Our results for the "buy" strategy through investment in capital goods is more in line with results in Goedhuys and Veugelers (2012) using Brazilian firm-level data in a different time period than the one in Frank *et al.* (2016). They obtain this "buy" strategy to be associated with innovation outputs, especially with process innovations.

Seventh, the use of ICT-related technologies is only statistically significant for process and marketing innovations. The three included variables, use of ICT, investment in software and investment in hardware, are positive and statistically significant for process innovation. ICT and software are positive and significant for marketing innovation (in this case, the investment in hardware does not seem to be relevant). As in general, ICT inputs and related technology, are positive and statistically significant both for process and for marketing innovations, this might be indicative of them being used for improving productivity and new marketing methods. This result differs to the one obtained in Frank *et al.* (2016) for Brazil, since they obtain that software acquisition has a negative effect on innovation output. They hypothesize that with this investment Brazilian firms just automatize operational routines and basic infrastructure. However, Goedhuys and Veugelers (2012) find that ICT use contributes both to product and process innovation (the two considered innovation output measures in their paper).

Finally, as regards further controls included in estimation, belonging to a foreign company does not seem to encourage any type of innovation, older firms have in general a lower likelihood to innovate (which may indicate some exhaustion of innovation opportunities), firms with more than 100 workers are more likely to perform process innovations, firms with more than 200 workers both product and process innovations, firms between 50 and 100 workers both product and organizational, and marketing does not seem to be related to firm's size. In the second wave of the survey, it is less likely to innovate in product, process and marketing, and more likely to innovate in organizational. Controlling for whatever else in estimation there is not anymore much room left for the technological sector classification, since we only obtain a higher likelihood of product innovation associated to med tech manufacturing sectors. Finally, for the provinces in the country, those that stand out in terms of at least three of the four types of innovations are Azuay, Cotopaxi, Imbabura, Pichincha and Tungurahua y Orellana[5].

In addition to our main results in this section (included in Table I and previously commented), we have further performed two robustness checks. The results of the first robustness check appear in Table II, which considers the possibility of differential effects of explanatory variables by firms' size group. Regressors in this table appear as in Table I but also multiplied by a dummy variable that takes value one when the firm has more than 100 workers (large firms). From the cross product variables coefficients we can see whether a variable has an extra-effect for large firms as regards SMEs. Our results from Table II confirm that there are only few differences between large firms and SMEs. Among them, we highlight the ones we consider more relevant and clear. First, market share is relevant for large firms to perform organizational innovations. Second, property rights as a measure of protection for innovation only affects innovation and positively for large firms. Third, the presence of skill workers is more relevant for innovation in large firms (probably due to a more intensive use of skill workers and of higher quality). Finally, for large firms there is a positive role for innovation coming from firms' age that affects both product and process innovation.

Our second robustness check results appear in Table III. In this table, we are interested in finding out whether there is evidence of statistically significant persistence in innovation. Innovation is a cumulative process that may rely on previous innovation outcomes. To test for this possibility, related to learning-by-doing and success-breads-success in innovation activities, we introduce in our *tetravariate probit* model the lagged value of the corresponding dependent variable for each of the four types of innovations. Notice that in this robustness check our sample size goes down dramatically from 2,810 observations to 472. The reason is that there are only two available waves in our survey and for estimation with lagged dependent variables as regressors we can only estimate with the second wave of the survey and only with firms that are present the two waves (to have their information about the lagged dependent variables). As we indicated in our Data section above, there are only 472 firms present in the two survey waves. Even with this data limitation, however, we obtain from estimation in Table III that there is time persistence in all innovation outcomes, with the exception of process innovation, and that the highest persistence is obtained for product and marketing innovations (for other empirical studies about persistence in innovation output see Máñez *et al.*, 2009; Raymond *et al.*, 2010; Demmel *et al.*, 2017).

Table II. Estimation results from the tetravariate probit model for the firms' innovation choices (large firms *versus* SMEs)

Variables	(1) Product *dy/dx* (Aver. Marg. Eff.)	(2) Process *dy/dx* (Aver. Marg. Eff.)	(3) Organizational *dy/dx* (Aver. Marg. Eff.)	(4) Marketing *dy/dx* (Aver. Marg. Eff.)
Demand conditions				
Unsatisfied demand	0.00187*** (0.000667)	0.000302 (0.000660)	0.000242 (0.000598)	0.000606 (0.000629)
Unsatisfied demand * large	−0.000306 (0.00132)	9.73e-05 (0.00134)	−0.00188 (0.00120)	−0.000327 (0.00125)
Quality improvement	0.0962 (0.0798)	−0.0548 (0.0773)	0.0328 (0.0805)	0.0499 (0.0855)
Quality improvement * large	0.266 (0.190)	−0.109 (0.164)	−0.194 (0.149)	0.0882 (0.163)
*d*_Market research $t-2$	0.185** (0.0747)	0.0787 (0.0645)	0.175*** (0.0533)	0.163*** (0.0534)
*d*_Market research $t-2$ * large	0.102 (0.106)	−0.00667 (0.106)	−0.0777 (0.0738)	0.0442 (0.0757)
*d*_export $t-2$	−0.0299 (0.0341)	−0.0866** (0.0343)	0.00250 (0.0312)	−0.0607* (0.0343)
*d*_export $t-2$ * large	−0.00817 (0.0499)	0.0550 (0.0499)	0.00852 (0.0446)	0.0156 (0.0478)
Competition and market power				
Threat of competition	0.00347** (0.00165)	0.0139 (0.0101)	−0.00241 (0.00914)	0.0114 (0.00936)
Threat of competition * large	0.00120 (0.00334)	0.0135 (0.0187)	0.00175 (0.0159)	0.00437 (0.0197)
Threat of competition^2	–	−0.000150 (0.000125)	−7.22e − 07 (0.000115)	−0.000174 (0.000117)
Threat of competition^2 * large	–	−0.000204 (0.000230)	−1.55e − 05 (0.000199)	−1.83e − 05 (0.000238)
Market share $t-2$	0.130 (0.225)	−0.0458 (0.197)	−0.293 (0.211)	−0.204 (0.254)
Market share $t-2$ * large	−0.187 (0.300)	0.122 (0.313)	0.754*** (0.278)	−0.0881 (0.322)
Financial conditions				
*d*_group	0.00455 (0.0334)	0.0106 (0.0337)	0.0363 (0.0301)	0.0196 (0.0330)
*d*_group * large	0.0772 (0.0509)	0.0113 (0.0514)	0.00999 (0.0446)	0.0784 (0.0484)
Inf. support programs	0.0169*** (0.00636)	0.0236*** (0.00603)	0.0343*** (0.00549)	0.0338*** (0.00581)
Inf. support programs * large	0.00531 (0.0120)	0.00335 (0.0118)	−0.0312*** (0.0105)	−0.0167 (0.0108)
Relative productiv. $t-2$	−0.0505 (0.0540)	0.0932* (0.0528)	0.0767 (0.0523)	0.00829 (0.0526)
Relative productiv. $t-2$ * large	0.314 (0.223)	0.239 (0.253)	−0.0507 (0.193)	−0.00736 (0.201)
Appropriability				
Secrecy	−0.00413 (0.00280)	−0.00285 (0.00291)	−0.00186 (0.00274)	−0.00840*** (0.00288)
Secrecy*large	−0.000949 (0.00580)	−0.00668 (0.00678)	0.000665 (0.00534)	0.00822 (0.00629)
Safeguard	0.00289 (0.00208)	−0.00166 (0.00200)	0.00142 (0.00188)	0.00720*** (0.00200)
Safeguard * large	0.00866* (0.00486)	0.00567 (0.00512)	−0.00687 (0.00425)	−0.00533 (0.00465)

(*continued*)

Variables	(1) Product *dy/dx* (Aver. Marg. Eff.)	(2) Process *dy/dx* (Aver. Marg. Eff.)	(3) Organizational *dy/dx* (Aver. Marg. Eff.)	(4) Marketing *dy/dx* (Aver. Marg. Eff.)
Human capital				
*d*_skill	0.0740*** (0.0271)	0.0777*** (0.0269)	0.0511* (0.0267)	0.0260 (0.0268)
*d*_skill * large	1.757*** (0.113)	1.614*** (0.0647)	1.356*** (0.0793)	1.421*** (0.0758)
*d*_training $t-2$	0.195*** (0.0336)	0.204*** (0.0333)	0.0972*** (0.0283)	0.104*** (0.0303)
*d*_training $t-2$ * large	−0.0188 (0.0632)	−0.0374 (0.0650)	−0.0946* (0.0510)	−0.0678 (0.0548)
*d*_engineers	0.0700** (0.0290)	0.0579** (0.0281)	0.112*** (0.0251)	0.0805*** (0.0267)
*d*_engineers * large	−0.0247 (0.0461)	0.0298 (0.0471)	−0.0856** (0.0401)	−0.0603 (0.0431)
Investments for innovation				
Internal R&D $t-2$	0.0266*** (0.00810)	0.0312*** (0.0106)	0.00214** (0.000849)	0.00440 (0.00625)
Internal R&D $t-2$ * large	−0.0294* (0.0157)	0.0803 (0.0580)	0.0118 (0.00810)	−0.0533*** (0.0198)
External R&D $t-2$	0.0368 (0.0251)	0.0171 (0.0295)	0.0508* (0.0281)	0.0129 (0.0174)
External R&D $t-2$ * large	0.131 (0.154)	0.132 (0.205)	−0.0412 (0.0408)	−0.0135 (0.0359)
Internal * External R&D $t-2$	−0.00471 (0.00349)	0.0548 (0.0596)	0.00882 (0.00736)	0.00271 (0.00361)
Internal * External R&D $t-2$ * large	−0.0996 (0.0906)	−0.234* (0.134)	0.813 (0.660)	−0.00467 (0.0408)
*d*_fixed investment $t-2$	0.156*** (0.0198)	0.194*** (0.0186)	0.0748*** (0.0189)	0.0405** (0.0200)
*d*_fixed investment $t-2$ * large	−0.0282 (0.0456)	0.0130 (0.0436)	−0.0368 (0.0406)	0.0405 (0.0434)
ICT				
*d*_ICT	0.0613** (0.0297)	0.103*** (0.0290)	0.0184 (0.0261)	0.0667** (0.0265)
*d*_ICT * large	−0.0720 (0.0503)	−0.107** (0.0507)	0.0229 (0.0452)	−0.0921* (0.0472)
*d*_software $t-2$	0.0244 (0.0530)	0.133** (0.0565)	−0.0315 (0.0466)	0.102** (0.0447)
*d*_software $t-2$ * large	−0.0413 (0.0830)	0.126 (0.110)	0.166** (0.0685)	0.0183 (0.0704)
*d*_hardware $t-2$	0.0113 (0.0487)	0.124** (0.0505)	0.0496 (0.0418)	0.0541 (0.0428)
*d*_hardware $t-2$ * large	0.0511 (0.0756)	0.143 (0.103)	−0.0201 (0.0629)	−0.0608 (0.0668)
Controls				
*d*_foreign	−0.0166 (0.0537)	−0.0982* (0.0543)	−0.0600 (0.0475)	−0.174*** (0.0561)
*d*_foreign * large	0.0641 (0.0684)	0.132* (0.0690)	0.0566 (0.0598)	0.0910 (0.0692)
Log age	−0.0104 (0.0129)	−0.0315** (0.0128)	−0.0312*** (0.0120)	−0.0135 (0.0127)
Log age*large	0.0564* (0.0299)	0.0523* (0.0293)	0.0316 (0.0265)	−0.0189 (0.0274)

(*continued*)

Table II.

Table II.

Variables	(1) Product dy/dx (Aver. Marg. Eff.)	(2) Process dy/dx (Aver. Marg. Eff.)	(3) Organizational dy/dx (Aver. Marg. Eff.)	(4) Marketing dy/dx (Aver. Marg. Eff.)
*d*_time	−0.0965*** (0.0210)	−0.0601*** (0.0207)	0.0342* (0.0198)	−0.0523*** (0.0201)
*d*_time*large	0.0501 (0.0440)	0.00288 (0.0445)	0.00885 (0.0392)	0.0490 (0.0419)
Med-Low tech manufacturing	0.0588** (0.0270)	−0.0330 (0.0267)	−0.0284 (0.0249)	−0.0319 (0.0263)
Med-Low tech manufacturing*large	0.0469 (0.0631)	0.0195 (0.0659)	0.0173 (0.0513)	0.0431 (0.0560)
Med-High tech manufacturing	0.126*** (0.0335)	−0.00929 (0.0336)	−0.0351 (0.0317)	0.00481 (0.0323)
Med-High tech manufacturing*large	−0.0593 (0.0663)	0.0417 (0.0703)	0.0317 (0.0618)	−0.0696 (0.0650)
High tech manufacturing	0.112* (0.0671)	0.0976 (0.0674)	0.0385 (0.0618)	0.0110 (0.0656)
High tech manufacturing*large	−0.0996 (0.133)	−0.0645 (0.130)	−0.0755 (0.108)	0.0983 (0.112)
Size 3&4 ($> = 100$) $t-2$	−2.752*** (0.418)	−2.092*** (0.500)	−0.936** (0.439)	−1.572*** (0.541)
Observations	2,810	2,810	2,810	2,810
Log pseudo-likelihood	−56,72.9688			
Correlation coefficients	$\rho_{12} = 0.570$, p-value = 0.000; $\rho_{13} = 0.234$, p-value = 0.000; $\rho_{14} = 0.266$, p-value = 0.000; $\rho_{23} = 0.266$, p-value = 0.000; $\rho_{24} = 0.248$, p-value = 0.000; $\rho_{34} = 0.358$, p-value = 0.000			

Table III. Estimation results from the tetravariate probit model for the firms' innovation choices (checking for persistence/cumulativeness)

Variables	(1) Product *dy/dx* (Aver. Marg. Eff.)	(2) Process *dy/dx* (Aver. Marg. Eff.)	(3) Organizational *dy/dx* (Aver. Marg. Eff.)	(4) Marketing *dy/dx* (Aver. Marg. Eff.)
Persistente/Cumulativeness				
Product (previous wave)	0.146*** (0.0361)			
Process (previous wave)		0.0332 (0.0411)		
Organizational (previous wave)			0.0697* (0.0400)	
Marketing (previous wave)				0.126*** (0.0368)
Demand conditions				
Unsatisfied demand	0.00156 (0.00128)	−0.000812 (0.00130)	0.00187 (0.00141)	0.00229* (0.00128)
Quality improvement	0.164 (0.215)	−0.275 (0.212)	−0.357 (0.245)	−0.123 (0.197)
*d*_Market research $t-2$	0.281*** (0.0978)	0.0104 (0.100)	0.0149 (0.0852)	0.163* (0.0843)
*d*_export $t-2$	0.0544 (0.0484)	−0.000343 (0.0483)	−0.0207 (0.0490)	−0.0584 (0.0488)
Competition and market power				
Threat of competition	0.00374 (0.00352)	−0.0522 (0.0337)	−0.0118 (0.0230)	0.143*** (0.0441)
Threat of competition^2	–	0.000609 (0.000397)	0.000185 (0.000277)	−0.00166*** (0.000510)
Market share $t-2$	−0.719*** (0.264)	−0.199 (0.266)	0.208 (0.259)	0.0407 (0.349)
Financial conditions				
*d*_group	−0.00133 (0.0539)	0.0573 (0.0521)	−0.00713 (0.0531)	0.0182 (0.0498)
Inf. support programs	0.00373 (0.0121)	0.0165 (0.0116)	0.00398 (0.0119)	0.0143 (0.0115)
Relative productiv. $t-2$	0.385* (0.224)	0.678*** (0.234)	−0.0251 (0.200)	−0.0943 (0.186)
Appropriability				
Secrecy	0.00287 (0.00682)	−0.00215 (0.00745)	0.00597 (0.00724)	0.00229 (0.00757)
Safeguard	0.00448 (0.00472)	−0.00368 (0.00449)	−0.00132 (0.00466)	−0.00406 (0.00519)
Human capital				
*d*_skill	0.570*** (0.209)	0.543*** (0.167)	0.274** (0.133)	0.335** (0.157)
*d*_training $t-2$	0.0885 (0.0610)	0.285*** (0.0616)	0.0607 (0.0556)	0.0388 (0.0539)
*d*_engineers	0.0275 (0.0444)	−0.0277 (0.0462)	0.133*** (0.0434)	0.104** (0.0417)

(*continued*)

Table III.

Variables	(1) Product dy/dx (Aver. Marg. Eff.)	(2) Process dy/dx (Aver. Marg. Eff.)	(3) Organizational dy/dx (Aver. Marg. Eff.)	(4) Marketing dy/dx (Aver. Marg. Eff.)
Investments for innovation				
Internal R&D $t-2$	0.388*** (0.121)	0.0381*** (0.0147)	−0.0430 (0.0475)	−0.00349 (0.0180)
External R&D $t-2$	0.0134 (0.0722)	−0.0794* (0.0478)	0.232 (0.216)	−0.0388 (0.0619)
Internal * External R&D $t-2$	−0.0285** (0.0121)	0.0121*** (0.00452)	0.0903 (0.282)	0.297 (0.180)
*d*_fixed investment $t-2$	0.151*** (0.0435)	0.199*** (0.0399)	0.0785* (0.0465)	0.0302 (0.0445)
ICT				
*d*_ICT	−0.0240 (0.0503)	0.110** (0.0524)	0.0407 (0.0531)	−0.0125 (0.0482)
*d*_software $t-2$	0.179** (0.0903)	0.127 (0.0958)	0.164** (0.0754)	0.171** (0.0778)
*d*_hardware $t-2$	−0.0197 (0.0695)	0.113 (0.0763)	0.0693 (0.0667)	0.0230 (0.0688)
Controls				
*d*_foreign	0.0357 (0.0622)	0.00267 (0.0621)	−0.00647 (0.0622)	−0.0582 (0.0606)
Log age	−0.0165 (0.0348)	0.0300 (0.0349)	0.0130 (0.0349)	−0.0424 (0.0365)
Size2 (> = 50,<100) $t-2$	0.0491 (0.0599)	0.0169 (0.0601)	0.0149 (0.0611)	0.114* (0.0608)
Size3 (> = 100,<200) $t-2$	−0.0908 (0.0670)	−0.0962 (0.0725)	−0.0297 (0.0705)	0.0548 (0.0690)
Size4 (> = 200) $t-2$	0.0240 (0.0712)	−0.00281 (0.0720)	−0.00599 (0.0738)	0.102 (0.0725)
Med-Low tech manufacturing	0.0574 (0.0603)	−0.0584 (0.0586)	−0.0257 (0.0550)	−0.0342 (0.0622)
Med-High tech manufacturing	−0.0370 (0.0698)	0.114 (0.0693)	−0.169** (0.0766)	−0.126* (0.0710)
High tech manufacturing	−0.118 (0.156)	0.0101 (0.133)	−0.00172 (0.130)	0.153 (0.150)
Observations	472	472	472	472
Log pseudo-likelihood	−892.34272			
Correlation coefficients	$\rho_{12} = 0.580$, p-value = 0.000; $\rho_{13} = 0.259$, p-value = 0.000; $\rho_{14} = 0.220$, p-value = 0.000; $\rho_{23} = 0.298$, p-value = 0.000; $\rho_{24} = 0.396$, p-value = 0.000; $\rho_{34} = 0.478$, p-value = 0.000			

Concluding remarks

The widespread results obtained are as follows. First, in general, good firms' demand conditions encourage innovation. Second, sectors with more competition create incentives for innovation but this relationship is not necessarily linear since there is certain evidence of an inverted-U shape relationship. Third, better financial prospects and more information on public support programs enhances the chances to innovate. Fourth, sectors relying on appropriability instruments based on secrecy agreements represent a barrier to innovation. The opposite is found for sectors basing it on the use of IPRs. Fifth, human capital is a relevant dimension for the firms' capability to innovate. Sixth, external and (mainly) internal R&D is relevant for innovation. Seventh, the use of ICT related technologies is also relevant. Finally, firms with less than 50 employees or older firms are less likely to innovate. In addition, there is less innovation associated to the second wave of the survey (2014 versus 2011). Furthermore, once controlling for everything else, the technological sector classification has not much to tell. We will come back to these two final points below.

In this paper, by explaining firms' decisions about four different types of innovations we can uncover some differences in drivers of innovation according to innovation type. For instance, demand conditions related to the existence of unsatisfied demand or the necessity of quality improvements in the market are only relevant for product innovation. Next, the threat of competition does not affect organizational innovation, and participation in exports only affects (and negatively) process and marketing innovations. In addition, there is a self-selection of the most productive firms into process innovations. Organizational innovation relies more on external R&D and marketing more on internal R&D. Furthermore, ICT related technologies appear non-relevant for product and organizational innovations. Marketing is not related to firms' size. Also, in the second period, all propensities to innovate decrease with the exception of organizational innovation that increases. Finally, med tech manufacturing *per se* seems more likely to product innovation than any other technological sector.

One important question to answer is why there is less innovation in the second wave of the survey, with the exception of organizational innovation that increases in 2014 with respect to 2011. We should look for the answer searching for innovation drivers that decrease from one period to the next in Ecuador. One of these variables is *threat of competition*, which perception by firms decreases in 2014 and that appeared non-relevant for organizational innovation. In addition, the sectoral use of secrecy agreements to protect innovation, which reduced innovation incentives for process and marketing innovations, increases in 2014. This makes spillovers more difficult and harder the capacity to imitate, learn and profit from external knowledge. Furthermore, both external and (especially) internal R&D investments are reduced in 2014. Since internal R&D was more related to product, process and marketing innovations than organizational innovation (only affected by external R&D), it is not surprising that the most hurt innovation types in 2014 are product, process and marketing innovations, and not so much organizational innovations. Finally, process and marketing innovations incentives can also be reduced in 2014 because of a lower investment in hardware (that was positively related to process innovation) and in software (that was positively related to marketing innovation).

We have something to say about the technological sector classification, which role probably was neglected in estimation once controlling for the rest of regressors. According to our descriptive analysis, there was a clear differentiation between low and med-low tech sectors versus med-high and high tech sectors. The second group was more innovative as regards the four types of innovations, and this was due to more demand driven incentives (making them to invest more often in fixed capital and market research), more spread use of property rights, more likely existence of skill workers and engineers, more likely investment in training, more effort in both external and (mainly) internal R&D, more spread use of ICT and more prone to invest in software and hardware.

As regards our robustness for firms' size, the most remarkable differences for large firms are that property rights are more important for innovation and that they count very likely with more skill workers and of higher quality.

Furthermore, although with a limited sample size from the original one, we have found certain evidence about persistence in the innovative process that may signal to the accumulative nature of it.

Finally, to conclude, one relevant result from the paper is that for Ecuadorian firms, as in other developing countries, the acquisition of technology incorporated in capital goods is even a more relevant input for innovation than the investment in R&D. This highlights in general the way innovative processes are carried out in developing countries, mostly supply dominated by the acquisition of equipment and machinery (embodied knowledge). As a special case, this is particularly true also for Ecuadorian firms, which innovative process seems to be supply dominated. Even though, there is also room for demand-driven innovation strategies behind the performance of activities such as market research, or the detection of market needs and niches (in these latter cases especially for product innovation).

Notes

1. From an empirical point of view, Beneito *et al.* (2015) or Máñez *et al.* (2014), find evidence of a negative impact of financial constraints on R&D investments.
2. Beneito *et al.* (2015) find that belonging to a group alleviates the role played by credit constraints in explaining firms' R&D investments.
3. The most relevant information about provinces is to highlight that only three provinces account for close to 70% of firms' observations: 12% Azuay, 25% Guayas, and 31% Pichincha.
4. Notice that most of firm-level regressors are lagged two periods to avoid simultaneity problems. Differently, industry-level regressors are referred to period *t*, since are constructed with information that the survey only provides for period *t*. The information on the timing of each regressor is provided both in Appendix 1 and in Tables I-III of results from estimation.
5. For the sake of brevity, we do not include in the Tables estimation results for the provinces.

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Appendix 1

Variables	Description
Demand conditions	
Unsatisfied demand	The ratio (%) of innovative firms in your sector-wave of the survey (at 2-digit sector level according to ISIC Rev 4. classification) that declare as reason for performing activities directed to innovation, the detection of an unsatisfied demand in the product market
Quality improvement	The higher the value of this indicator, the higher the relative importance for a sector in a particular wave of the survey (at 2-digit sector level according to ISIC Rev 4. classification) of the objective of improving the quality of products when pursuing innovation
d_Market research $t-2$	Dummy variable taking value 1 if the firm invests in market research in period $t-2$, and 0 otherwise
d_export $t-2$	Dummy variable taking value 1 if the firm exports in period $t-2$, and 0 otherwise
Competition and market power	
Threat of competition	The ratio (%) of innovative firms in your sector-wave of the survey (at 2-digit sector level according to ISIC Rev 4. classification) that declare as reason for performing activities directed to innovation, the threat of competition
Threat of competition^2	The squared ratio (%) of innovative firms in your sector-wave of the survey (at 2-digit sector level according to ISIC Rev 4. classification) that declare as reason for performing activities directed to innovation, the threat of competition
Market share $t-2$	Firms' sales over industry sales in period $t-2$. The industry sales are at 2-digit sector level according to ISIC Rev 4. classification
Financial conditions	
d_group	Dummy variable taking value 1 if the firm is member of a business group, and 0 otherwise
Inf. support programs	Number of public innovation support programs that the firm is aware of (maximum of six programs)
Relative productiv. $t-2$	The denominator of this ratio is the sector mean of the sales per employee (in log terms) at 2-digit sector level according to ISIC Rev 4. classification. The numerator is the sales per employee (in log terms) of the firm. Both parts use the period $t-2$
Appropriability	
Secrecy	The ratio (%) of innovative firms in your sector-wave of the survey (at 2-digit sector level according to ISIC Rev 4. classification) that declare the use of clauses or secrecy agreements with employees, suppliers or clients to protect innovations
Safeguard	The ratio (%) of innovative firms in your sector-wave of the survey (at 2-digit sector level according to ISIC Rev 4. classification) that declare the use of trademarks, certificates of origin, copyrights, industrial designs, patents, or utility models to protect innovations
Human capital	
d_skill	Dummy variable taking value 1 if the firm has employees with PhDs, Master or some University degree, and 0 otherwise
d_training $t-2$	Dummy variable taking value 1 if the firm invests in workforce training in period $t-2$, and 0 otherwise
d_engineers	Dummy variable taking value 1 if the firm has workforce dedicated to engineering and industrial design, and 0 otherwise

(*continued*)

Table AI. Variables description

Variables	Description
Invest. for innovation	
Internal R&D $t-2$	Expenditure on internal R&D over firms' sales (%) in period $t-2$
External R&D $t-2$	Expenditure on external R&D over firms' sales (%) in period $t-2$
Internal*External R&D $t-2$	Cross product of internal and external R&D intensities (%) in period $t-2$
*d*_fixed investment $t-2$	Dummy variable taking value 1 if the firm invests in fixed capital in period $t-2$, and 0 otherwise
ICT	
*d*_ICT	Dummy variable taking value 1 if the firm has a formal department of Information and Communication Technologies (ICT), and 0 otherwise
*d*_software $t-2$	Dummy variable taking value 1 if the firm invests in software in period $t-2$, and 0 otherwise
*d*_hardware $t-2$	Dummy variable taking value 1 if the firm invests in hardware in period $t-2$, and 0 otherwise
Controls	
*d*_foreign	Dummy variable taking value 1 if the firm has foreign capital participation, and 0 otherwise
Log age	Number of years since the firm was born
Size1 (<50) $t-2$	Dummy variable taking value 1 if the firm has less than 50 employees, and 0 otherwise
Size2 (> = 50,<100) $t-2$	Dummy variable taking value 1 if the firm has more than 50 employees and less than 100, and 0 otherwise
Size3 (> = 100,<200) $t-2$	Dummy variable taking value 1 if the firm has more than 100 employees and less than 200, and 0 otherwise
Size4 (> = 200) $t-2$	Dummy variable taking value 1 if the firm has more than 200 employees, and 0 otherwise
*d*_time	Dummy variable taking value 1 for observations corresponding to the second wave of the survey, and 0 otherwise
Low tech manufacturing	Dummy variable taking value 1 if the firm is in manufacturing low technology intensity sectors according to NACE Rev. 2 classification, and 0 otherwise
Med-Low tech manufacturing	Dummy variable taking value 1 if the firm is in manufacturing Medium Low technology intensity sectors according to NACE Rev. 2 classification, and 0 otherwise
Med-High tech manufacturing	Dummy variable taking value 1 if the firm is in manufacturing Medium High technology intensity sectors according to NACE Rev. 2 classification, and 0 otherwise
High tech manufacturing	Dummy variable taking value 1 if the firm is in manufacturing High technology intensity sectors according to NACE Rev. 2 classification, and 0 otherwise
Provinces	Dummy variables taking value 1 if the firm is located in a particular province of the country and 0 otherwise

Table AI.

Appendix 2. Descriptive statistics

Variables	Mean	SD
Product	0.42	0.49
Process	0.48	0.50
Organizational	0.25	0.43
Marketing	0.27	0.45
All innovations	0.07	0.26
At least one innovation	0.68	0.47
Unsatisfied demand	51.00	15.98
Quality improvement	1.16	0.12
*d*_Market research $t-2$	0.04	0.20
*d*_export $t-2$	0.20	0.40
Threat of competition	42.33	7.21
Threat of competition^2	1843.98	576.63
*d*_group	0.17	0.38
Inf. support programs	1.65	1.64
Relative productiv. $t-2$	1.00	0.18
Secrecy	12.99	4.59
Safeguard	20.22	6.02
*d*_skill	0.88	0.32
*d*_training $t-2$	0.13	0.34
*d*_engineers	0.20	0.40
Internal R&D $t-2$	0.37	6.45
External R&D $t-2$	0.05	0.55
Internal*External R&D $t-2$	0.11	2.91
*d*_fixed investment $t-2$	0.49	0.50
*d*_ICT	0.29	0.45
*d*_software $t-2$	0.06	0.24
*d*_hardware $t-2$	0.08	0.27
*d*_foreign	0.09	0.29
Log age	2.85	0.80
Size1 (<50) $t-2$	0.63	0.48
Size2 (> = 50,<100) $t-2$	0.13	0.33
Size3 (> = 100,<200) $t-2$	0.10	0.30
Size4 (> = 200) $t-2$	0.14	0.35
*d*_time	0.58	0.49
Low tech manufacturing	0.55	0.50
Med-Low tech manufacturing	0.31	0.46
Med-High tech manufacturing	0.12	0.32
High tech manufacturing	0.02	0.15

Table AII.
Total manufacturing (2,810 obs)

Table AIII.
Descriptive statistics (means) by size (number of employees)

Variable	(<50) 63.41%	(50-100) 12.81%	(100-200) 9.89%	>=200 (13.88%)
Product	0.38	0.46	0.49	0.56
Process	0.42	0.49	0.60	0.66
Organizational	0.22	0.29	0.29	0.34
Marketing	0.26	0.29	0.31	0.29
Unsatisfied demand	51.70	49.93	49.54	49.81
Quality improvement	1.16	1.16	1.17	1.17
*d*_Market research $t-2$	0.03	0.02	0.08	0.13
*d*_export $t-2$	0.06	0.23	0.39	0.69
Threat of competition	42.69	41.43	41.65	42.00
Threat of competition^2	1874.16	1773.41	1789.14	1810.29
*d*_group	0.08	0.17	0.28	0.49
Inf. support programs	1.44	1.72	2.05	2.31
Relative productiv. $t-2$	0.97	1.04	1.05	1.06
Secrecy	12.48	13.47	14.12	14.09
Safeguard	19.54	20.46	21.32	22.33
*d*_skill	0.82	0.98	1.00	0.99
*d*_training $t-2$	0.09	0.17	0.20	0.22
*d*_engineers	0.11	0.24	0.38	0.43
Internal R&D $t-2$	0.47	0.20	0.14	0.24
External R&D $t-2$	0.06	0.00	0.08	0.03
Internal*External R&D $t-2$	0.17	0.00	0.05	0.00
*d*_fixed investment $t-2$	0.40	0.55	0.66	0.76
*d*_ICT	0.10	0.35	0.60	0.86
*d*_software $t-2$	0.04	0.07	0.11	0.13
*d*_hardware $t-2$	0.04	0.09	0.15	0.16
*d*_foreign	0.03	0.09	0.16	0.34
Log age	2.65	2.95	3.16	3.46
*d*_time	0.54	0.63	0.67	0.64
Low tech manufacturing	0.54	0.54	0.53	0.66
Med-Low tech manufacturing	0.33	0.30	0.28	0.22
Med-High tech manufacturing	0.11	0.12	0.15	0.09
High tech manufacturing	0.02	0.04	0.04	0.03

Variables	Low tech. 55.44%	Med-Low tech. 30.56%	Med-High tech. 11.53%	High tech. 2.45%
Product	0.40	0.41	0.53	0.52
Process	0.49	0.45	0.50	0.62
Organizational	0.25	0.24	0.25	0.35
Marketing	0.28	0.24	0.29	0.36
Unsatisfied demand	50.40	53.06	47.35	55.96
Quality improvement	1.18	1.14	1.16	1.12
*d*_Market research $t-2$	0.04	0.03	0.07	0.09
*d*_export $t-2$	0.22	0.17	0.22	0.22
Threat of competition	45.25	37.54	42.25	36.59
Threat of competition^2	2077.79	1454.47	1847.33	1397.95
*d*_group	0.17	0.17	0.20	0.12
Inf. support programs	1.65	1.56	1.86	2.04
Relative productiv. $t-2$	1.00	1.00	1.00	1.00
Secrecy	12.00	13.08	16.79	16.42
Safeguard	21.10	16.45	24.80	25.82
*d*_skill	0.87	0.87	0.94	0.99
*d*_training $t-2$	0.12	0.13	0.19	0.16
*d*_engineers	0.16	0.23	0.29	0.29
Internal R&D $t-2$	0.15	0.32	1.44	0.95
External R&D $t-2$	0.04	0.05	0.07	0.10
Internal*External R&D $t-2$	0.17	0.03	0.03	0.25
*d*_fixed investment $t-2$	0.49	0.48	0.50	0.61
*d*_ICT	0.29	0.24	0.34	0.42
*d*_software $t-2$	0.06	0.05	0.11	0.12
*d*_hardware $t-2$	0.07	0.07	0.12	0.20
*d*_foreign	0.09	0.08	0.13	0.10
Log age	2.85	2.83	2.92	2.95
Size1 (<50) $t-2$	0.62	0.68	0.63	0.46
Size2 (> = 50,<100) $t-2$	0.12	0.13	0.14	0.22
Size3 (> = 100,<200) $t-2$	0.09	0.09	0.13	0.17
Size4 (> = 200) $t-2$	0.16	0.10	0.11	0.14
*d*_time	0.58	0.54	0.62	0.68

Table AIV. Descriptive statistics (means) by technological sector

Table AV. Descriptive statistics (means) by survey wave

Variables	2011 1191 obs.	2014 1619 obs.
Product	0.48	0.39
Process	0.50	0.46
Organizational	0.22	0.28
Marketing	0.29	0.26
Unsatisfied demand	56.73	46.78
Quality improvement	1.14	1.18
*d*_Market research $t-2$	0.05	0.04
*d*_export $t-2$	0.18	0.22
Threat of competition	43.05	41.80
Threat of competition^2	1900.99	1802.04
*d*_group	0.16	0.18
Inf. support programs	1.44	1.81
Relative productiv. $t-2$	1.00	1.00
Secrecy	12.32	13.49
Safeguard	19.60	20.68
*d*_skill	0.86	0.90
*d*_training $t-2$	0.13	0.13
*d*_engineers	0.15	0.24
Internal R&D $t-2$	0.59	0.21
External R&D $t-2$	0.06	0.04
Internal * External R&D $t-2$	0.13	0.10
*d*_fixed investment $t-2$	0.47	0.51
*d*_ICT	0.25	0.31
*d*_software $t-2$	0.06	0.06
*d*_hardware $t-2$	0.08	0.08
*d*_foreign	0.07	0.11
Log age	2.84	2.86
Size1 (<50) $t-2$	0.69	0.59
Size2 (> = 50,<100) $t-2$	0.11	0.14
Size3 (> = 100,<200) $t-2$	0.08	0.12
Size4 (> = 200) $t-2$	0.12	0.15
Low tech manufacturing	0.55	0.56
Med-Low tech manufacturing	0.33	0.29
Med-High tech manufacturing	0.10	0.12
High tech manufacturing	0.02	0.03

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