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COOPERATION IN THE FIELD OF INNOVATION, ABSORPTIVE CAPACITY, PUBLIC FINANCIAL SUPPORT AND DETERMINANTS OF THE INNOVATIVE PERFORMANCE OF ENTERPRISE

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The aim of this paper is to better understand whether cooperation, absorptive capacity and public financial support for innovation activities, how they influence the innovative performance of Portuguese enterprise. The literature review focuses the importance of these three factors both drivers as the limiters process of business innovation, influencing the innovative performance of enterprise. Based on a review of the literature, hypotheses are formulated, which are tested with secondary data resources from the Community Innovation Survey 2010. This questionnaire was implemented under the supervision of EUROSTAT. The method used is the logistic regression model. The results obtained confirm that the implementation of cooperation with partners belonging to internal sources of business has a significant influence on the innovations achieved at the level of both products and processes.

Keywords: Innovation; cooperation; absorption capacity; public financial support; CIS.

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Introduction

In the context of globalization, innovation assumes great importance, with an impact on all sectors of activity and at the level of society in general, being seen as the key factor in the competitiveness of companies and even nations. In this sense Hirsch-Kreinsen *et al.* (2008, p. 3) refer "as the European Union evolves into a knowledge society, the ability to generate, use, diffuse and absorb new knowledge is increasingly viewed as critical to economic success and societal development. Sustainable competitive advantages depend increasingly on the innovation capacity of a company and consequently are reflected in its innovative performance. Accordingly, it becomes necessary to gain a deeper knowledge of the innovation process, focusing mainly on the factors that drive and limit business innovation.

The innovative performance varies from company to company and is determined by a vast and complex combination of factors, both drivers of and limiters to the process of business innovation. The explanatory factors of innovation mentioned here are not exhaustive, and in this work we consider cooperation, absorptive capacity and public financial support for innovation activities.

Thus, this research aims to identify the determinants of innovation that influence the innovative performance of Portuguese enterprise. The present study, as its theoretical framework of reference, adopts different approaches to business innovation, namely the systemic approach to innovation, networks, resources and capabilities and the open innovation approach. Whereas the innovation process between the company and its surroundings is not linear, evolutionary, complex and interactive, this study aims to develop theoretical support based on the current approaches, corroborated by empirical support; that is, it intends fundamentally to identify and analyze the factors that influence and stimulate the activity and the innovation performance of companies.

To test the hypotheses formulated, secondary data belonging to the Community Innovation Survey 2010 are used (CIS, 2010). This questionnaire has been implemented in several countries in Europe under the supervision of EUROSTAT. The method used is the logistic regression model.

It is expected that the results will contribute to deeper knowledge of the theme and fill some gaps both at the level of theoretical contributions and at the empirical level. In addition, the study intends to generate knowledge and propose guidelines to assist public and private entities in the formulation of measures aimed at the opening of companies by sharing knowledge to boost innovation and the promotion of innovative performance.

After this first introductory section, the chapter is composed of four sections. Section 2 presents a review of the literature regarding the determinants of

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innovation. Section 3 sets out the methodology, describes the sample and the data used in the empirical study and subsequently presents the regression models used. Section 4 performs an analysis of the results, and the main conclusions appear in the last section.

Review of the Literature

Compared with the current scenario of intense competition and immense competitiveness, entrepreneurs probably have only one path to follow: innovation. Innovation, in addition to the desire of entrepreneurs, involves costs and needs a considerable amount of time and changes in the structure of the company to make it flexible enough to accommodate the changes that must be imposed. All changes are a reflection of a vast and complex collection of factors, both drivers of and limiters to the process of business innovation, influencing the innovation performance of companies. Given the diversity of explanatory factors of innovation, this work considers: cooperation, absorptive capacity and public financial support. Thus, the literature review focuses the importance of these three factors both drivers as the limiters process of business innovation, influencing the innovative performance of enterprise.

Innovative performance

Companies need to innovate not only to grow in a favorable manner but also to survive and resist the current market (Cefis and Marsili, 2006). The innovative performance and/or the innovative capacity of companies has already been the object of analysis in previous studies, in particular Roberts and Amit (2003), Silva *et al.* (2005) and Berchicci (2013). The present study considers the innovative performance of a company as something that integrates the various components resulting from its process of innovation; this research work highlights product and process innovation.

Product innovation is the introduction of a new, or significantly improved, good or service, taking into account its characteristics or uses. It also includes improvements in technical specifications, components and materials, embedded software, easier use and other functional characteristics (OECD, 2005). Therefore, innovations in products synthesize the use of new knowledge or new technologies and new uses as well as combinations of already-existing knowledge and technologies (OECD, 2005). In accordance with the CIS 2010, product innovation allows better performance of a good or service as well as an increase in its applications. Thus, attempts to improve the quality of goods and to increase the

efficiency and/or the speed of services are the main objectives mentioned by Conceição and Ávila (2001) and OECD (2005) that serve as motivation for product innovation.

Process innovation is 'the implementation of a production process or a distribution method or an activity of support for their goods and services, new or significantly improved, or an activity to support their goods or services also new or significantly improved' (CIS, 2010, p. 5). The result of process innovation can have a significant impact on production, logistics, delivery or distribution or even support activities, and whether the innovation was originally developed by the company or another is not relevant (CIS, 2010).

Thus, in this research we adopt the term innovative performance of the company to consider the two components resulting from the process of innovation in a company, namely product innovation and process innovation.

Cooperation

Cooperation is a theme that has aroused the interest of many researchers, as stressed by the literature review. Cooperation is an important factor for the creation of technological skills (Schoenmakers and Duysters, 2006) and is a viable solution to a problem common to many companies: resources and capabilities are not always available within the company and are difficult to obtain efficiently on the market (Tsai, 2009). It is expected that cooperation will provide other benefits, such as the achievement of economies of scale, reducing uncertainty and risk and gaining access to new markets and new additional knowledge (Miotti and Sachwald, 2003).

Cooperation for innovation, according to the CIS (2010, p. 10), refers to "active participation in innovation projects with other companies or non-commercial institutions. The cooperation agreement does not imply that both partners withdraw trade benefits. The simple hiring abroad, without any active collaboration of the company, is not considered cooperation." The importance of cooperation for innovation has been increasing due to technological progress, increased costs and the sharing of risky economic activities, among other factors that promote innovation.

The role of cooperation in R&D has become increasingly important in the midst of business life, and many authors have addressed the topic, including issues such as whether innovative activities with other companies or institutions are opportunities to gain access to complementary technological resources and to enable faster development and better access to the market in addition to allowing diversification and the sharing of the cost and risk (Hagedoorn, 2002; Silva, 2003; Robin and Schubert, 2013).

In a study carried out in Portugal, which used the database of the "Portuguese Third Community Innovation Survey", Silva and Leitão (2009) affirmed that companies that establish relationships of cooperation with universities and other educational institutions have a greater propensity to achieve groundbreaking advancements. They also emphasized that companies that establish relationships with customers, suppliers or groups of companies have a greater propensity to innovate than firms that do not cooperate. When confronted with the facts presented, it is evident that cooperation in the field of innovation significantly influences the innovative process of enterprises and provides several benefits to those companies. The role of suppliers and customers in the innovation process is also emphasized: the first because they are in permanent contact with the customers' needs and have to introduce amendments and innovations to be able to continue to meet their needs; and the second because they are constantly looking for new products and require companies that differentiate themselves by innovating. However, the surrounding environment of companies also influences their innovative capacity. Examples of this are the local public administration, business associations, banks, regional agencies or professional schools that provide companies with support in the form of financial resources and qualifications of the labor force and reinforce the innovation capacity of the local industry (Schmitz and Musyck, 1994).

Networking is seen today as fundamental for all companies, institutions or even people on an individual basis. It is networks that often build the solution to many of the problems of businesses, from supplying new markets to new forms and methods of production. "The networks increase the value of the individual and the individual increases the value of networks'; closeness, the human scale and confidence are forces of cohesion that ensure a network (Gouveia, 2012, p. 98). It is perceived that firms do not innovate in isolation from their surrounding environment and that innovation is influenced by both internal and external factors (Silva, 2003; De Faria *et al.*, 2010).

Cooperation in the field of innovation established with partners from the surrounding environment means that companies must, from the outset, monitor all their sources of information, removing each one necessary to remain competitive and make their products more attractive to the market. Thus, it is imperative that companies are alert to their surroundings and have the ability to anticipate change, always keeping one step ahead of the competition. The connection to research centers and universities has decreased the need for business investment in innovation and has proved to be an attractive and decisive factor to ensure innovative capacity in new ways.

In this work, innovation is seen as the result of an interactive learning process, involving the interactions between users and producers (Lundvall, 1992), the

interactions between companies and other institutions providing knowledge and training (universities and institutions of higher education, consultants, commercial laboratories and centers of research and development (R&D), state laboratories and governmental R&D institutes) or the interactions between other partners (Lundvall, 1992; Kaufmann and Tödtling, 2000, 2001; Silva, 2003; De Faria *et al.*, 2010).

According to Drucker (1985), the sources of innovation can be internal or external to the organization. Chesbrough (2003) reported, regarding the control in intramural innovation, the characteristic of a closed innovation, which, being confined to the company's own organizational culture, has underlying internal cooperation between the various elements that constitute it. In this type of innovation, the whole process is generated internally without interaction with the outside world; that is, from the generation of the idea to its marketing, all the tasks are performed by the organization itself. However, one of the criticisms to highlight is that the ideas and existing technologies may not be accessible or may not have the required quality (Herzog, 2011).

In the closed innovation model, the innovation is always dependent on the human resources of the company and their competences and skills in obtaining new ideas, emerging as a cycle of innovation within the organization, the investments of which are processes at the level of human resources and design and development. In this type of culture, there is a conviction that the competitive advantage over the competition comes from the pioneering role in the market. In this way, it generates a virtuous cycle, leading to the profits made being reinvested to improve and generate new ideas. The intellectual property is thus protected, restricting or even preventing competitors from profiting and exploiting innovations and emerging technologies (Chesbrough, 2003).

Open innovation comes from the use of input and output of knowledge flows that allow the acceleration of the domestic innovation and the expansion of the market for external use. This paradigm assumes that, to advance their technologies, companies can and must use both external and internal ideas as well as following internal and external paths to the market. These are the intellectual property of innovations according to their origin and may take different forms, such as licensing contracts (Chesbrough, 2003). In this way, both internal and external ideas appear with the same level of importance as the distribution channels that are internal or external to the organization (Chesbrough, 2006). The open innovation model of Chesbrough (2007), as well as Chesbrough *et al.* (2006) and Berchicci (2013), relates the importance of external sources of technology from partners as determinants of the final result of the innovative performance of the company.

The role of cooperation in companies' innovative process has been increasing due to technological progress as well as the sharing of costs and risk. Several authors have affirmed that innovative activities with other companies or institutions are opportunities to gain access to additional technological resources and allow more rapid development and improved market access (Cassiman and Veugelers, 2002; Hagedoorn, 2002).

The recognition of the importance of the sources of information and cooperation for the activities of product innovation and process has gained importance over the last few years (Gomes *et al.*, 2012). In this context, there were several authors who stated that the internal and external sources of information and cooperation are complementary and not substitutes (Cassiman and Veugelers, 2002).

In this research, taking the CIS, 2010 as a basis, the sources of information and cooperation for the activities of product innovation and process are grouped into four variables, following other empirical investigations (Loureiro, 2011; Mention, 2011). Thus, the variables tested in the study are internal sources (Fint), market sources (Fmerc), institutional sources (Finst) and other sources (FOutras).

Each of the sources of information and cooperation is associated with a theoretical hypothesis, with the aim of obtaining knowledge about the influences that these forms of cooperation exert on the innovative performance and the level of innovation in products and processes. Thus, the study establishes the following relationship between cooperation in the context of innovation and innovative performance:

Hypothesis 1: *The realization of cooperation with partners in the context of innovation positively influences the propensity to innovate.*

On the basis of the generic hypothesis related to the partners establishing cooperation in the field of innovation and with the typology presented in the Innovation Survey CIS 2010, the following four specific assumptions are formulated in this context:

Hypothesis 1.1: *The realization of cooperation with partners belonging to internal sources of the company is positively related to its propensity to innovate.*

Hypothesis 1.2: *The realization of cooperation with partners belonging to the sources of the market is positively associated with the propensity to innovate.*

Hypothesis 1.3: *The realization of cooperation with partners belonging to the institutional sources is positively associated with the propensity to innovate.*

Hypothesis 1.4: *The realization of cooperation with partners belonging to other sources is positively associated with the propensity to innovate.*

In this follow-up, innovation is the result of an interactive process between the company and its surrounding environment as a result of the collaboration between a wide range of stakeholders, both inside and outside the company (Silva, 2003); that is, innovation can occur through internal or external factors. Thus arises the term cooperation, which is considered as a stimulus for innovation and is expected to generate several benefits from the perspective of open innovation. In addition to cooperation, the literature has also emphasized the influence of absorptive capacity and public financial support.

Absorptive capacity

The concept of absorptive capacity has assumed importance over time due to the system dynamic capacity in the process of business innovation (Cohen and Levinthal, 1994; Zahra and George, 2002; Lane, Koka and Pathak, 2006; Camisón and Forés, 2010; Chang and Tzeng, 2010; Sun and Anderson, 2010; Patterson and Ambrosini, 2015).

Absorptive capacity is the ability to identify and use external knowledge that is relevant to internal innovative activities (Cohen and Levinthal, 1989, 1990). In this way, absorptive capacity involves not only the ability to identify and assimilate new external knowledge but also the ability to apply such knowledge for a business purpose (Cohen and Levinthal, 1990).

In accordance with Cohen and Levinthal (1989), innovative capabilities depend on the ability to exploit external knowledge and the R&D effort of the internal market. Powell and Brantley (1992) and Powell *et al.* (1996) referred to the internal capacities and external collaboration not superseding each other but rather complementing each other. The internal capacity enables the assessment of research that comes from outside, while external collaboration provides access to new features that may not be developed internally.

Zahra and George (2002) considered absorptive capacity as a dynamic capacity, through which the company acquires, assimilates, transforms and explores external information. These authors considered absorptive capacity to be required for the development of innovation processes.

The study by Zahra and George (2002) extended the concept originally defined by Cohen and Levinthal (1990), referring to absorptive capacity as a group of routines and organizational processes through which companies acquire, assimilate, transform and exploit knowledge to produce a dynamic organizational capacity. For these authors, absorptive capacity provides a competitive advantage to the company, a level of strategic flexibility, innovation and performance. In this context, Tzokas *et al.* (2015) stated that the application and effective use of knowledge on the part of the companies that purchase it require an ability

that enhances companies strategically in the generation of new products and/or services.

The literature review performed found a consensus that the absorptive capacity of an enterprise promotes and facilitates its innovative performance. Thus, the company, to cooperate with its partners, engages in the process of information exchange, whereby it gains new ideas and shares knowledge with the aim of acquiring, assimilating, transforming and exploiting knowledge (Zahra and George, 2002), subsequently fostering the creation of a product or process, or the significant improvement of the same, for the company and/or the market.

This research aims to determine whether companies that invest in better structures, technologies and qualified personnel have evidenced a higher propensity to innovate. Thus, it establishes the following relationship between absorptive capacity and propensity to innovate:

Hypothesis 2: *A company's absorptive capacity is positively associated with its propensity to innovate.*

The present research aims to establish whether companies that invest in innovation activities, in particular in internal and external R&D and qualified staff, have a greater propensity to innovate. On the basis of the generic hypothesis related to the indicators that can measure companies' absorptive capacity, and taking into account the data obtained through the innovation survey (CIS, 2010), the study formulates the following three specific assumptions in this context:

Hypothesis 2.1: *The qualifications of a company's human resources are positively associated with its propensity to innovate.*

Hypothesis 2.2: *An increase in the proportion of internal investments in R&D is positively associated with the propensity of a company to innovate.*

Hypothesis 2.3: *An increase in the proportion of foreign investments in R&D is positively associated with the propensity of a company to innovate.*

Public financial support

Public financial support appears as a factor in the promotion of the activities of business innovation (Silva *et al.*, 2009). Despite not being considered as a strategic factor, it emerges as one of the main constraints to the survival and development of enterprises (Silva and Raposo, 1999; Silva *et al.*, 2012).

In Portugal, in the context of financing, there is a high number of inefficiencies that matter (Silva, 2003), in particular a lack of connection, coordination and linkage between elements of the innovation system, revealed by the poor connection between companies and institutions that conduct research and promote

innovation (Oliveira, 2001). There is also poor use of the potential for the creation of partnerships between universities, laboratories and state enterprises (Stern, 2001), among other weaknesses in the system.

Other studies claim that governmental policies should support technological development, public investment policies, and support to innovation and cooperation with universities or national laboratories (Escribá and Murgui, 2009; Albors-Garrigos and Barrera, 2011; Doh and Kim, 2014; Bock *et al.*, 2018).

From this perspective, community financial support has been a central issue in the political agendas of the European Union. Regardless of the country, each government is responsible for regional and local factors that affect innovation (Doh and Kim, 2014), as well as for policies that improve access of companies to funds for infrastructure and information. They are also responsible for providing legal and financial bases to companies in favor of entrepreneurship and growth (Lee *et al.*, 2010). In this way, companies aggregate participants, dynamics, and opportunities that promote innovation, providing sources for new jobs, growth in exports and productivity. In short, the public policies for supporting innovation are tools that promote the activities of the companies.

Public financial support includes tax benefits, subsidies, low-interest loans, or bank guarantees. According to Lecerf (2012), Albors-Garrigos and Barrera (2011) and Bock *et al.* (2018), financial support is considered a fundamental prerequisite for the innovation projects of companies. It is one of the keys to improve the innovation of companies and regions, or the territories to which they belong. However, innovation can only occur if the ability to innovate exists in the companies, through the availability of resources, collaboration structures, and processes to solve problems. In the context of small-and medium-sized companies, the available resources are mainly related to financial factors and skilled workforce (Laforet, 2011). The capital is one of the resources that companies need to start, operate or grow, achieve an appropriate level of financing, it is a prerequisite for innovation activities (Xie *et al.*, 2013).

In accordance with Tourigny and Le (2004), the financial aid can reduce the obstacles that companies face in relation to innovation. In this way, it is important to examine how the public financing influences the development of innovation activities and consequently the innovative performance. Indeed, it is of utmost importance to study the impact of public financial support provided by state entities on innovation activities performed by Portuguese companies, in order to analyze their influence on business innovation activities. To do this, it presents the following hypothesis:

Hypothesis 3: *A company that benefits from public financial support has a greater propensity to innovate.*

Based on the hypothesis related to the general public financial support in the context of innovation and with the typology presented in the Innovation Survey (CIS, 2010), the study formulates the following three specific assumptions in this context:

Hypothesis 3.1: *Public financial support from the local/regional administration is positively associated with a company's propensity to innovate.*

Hypothesis 3.2: *Public financial support from the central administration is positively associated with a company's propensity to innovate.*

Hypothesis 3.3: *Public financial support from the European Union is positively associated with a company's propensity to innovate.*

Methodology

Following the elaboration of the theoretical support for the theme of this research and the formulation of the hypotheses, this chapter will present the data and the sample used as well as the methodology applied.

To carry out this research, it was essential to take a decision regarding the adoption of primary data and secondary data. In relation to primary data, the means available for the collection of data, in this case questionnaires and in-depth interviews with companies, did not make it possible to complete the investigation within the time limit to which it was subject. This is a result of the high probability of companies failing to reply to the questionnaires due to a lack of availability or resistance on the part of those surveyed as well as the large amount of time and resources required to obtain the totality of the surveys.

Given these facts, the decision was made to use secondary data; as Malhotra and Birks (2007) stated, when primary data become inaccessible or inappropriate, secondary data constitute the only possible solution and are a viable option, since they have the main advantage of being more economical and faster to obtain. The present research was conducted based on secondary data through access to (CIS, 2010).

Sample and database

The database used for this research is the Community Innovation Survey (CIS) 2010. The sample was created by the National Institute of Statistics (INE) and the process carried out by the Office of Planning, Strategy, Assessment and International Relations of the Ministry of Science, Technology and Higher Education (GPEARI/MCTES), under the supervision of EUROSTAT. The methodology

used in this inquiry is described in the *OECD Oslo Manual* and adopted across Europe through EUROSTAT (OECD, 2005). The CIS 2010 questionnaire provides detailed general data about companies, namely their sector of activity, number of employees, training and qualification of personnel, investments and expenditure on R&D activities, turnover, cooperation and public financial support.

Although some of the limitations associated with the questionnaire CIS, such as the lack of access to certain variables, the balance of the use of CIS 2010 is very positive, due to the quality and reliability of the information, as well as access to a large amount of data. These facts are corroborated by Laursen and Salter, (2006, p. 137): "the interpretability, reliability, and validity of the survey were established by extensive piloting and pre-testing before implementation within different European countries and across firms from a variety of industrial sectors, including services, construction and manufacturing".

In accordance with the methodological notes of the DGEEC (2012), the period of data collection occurred between July 2011 and April 2012, while the reference period was between 2008 and 2010. The consultancy GPEARI/MCTES, through authorization delegated by the National Institute of Statistics (INE), coordinated the process of inquiry with companies, collecting, treating and analyzing data related to innovation in Portugal.

The sample obtained after correction by the results of the examination consisted of 8,189 companies. In this sample, 6160 companies replied to the questionnaire, corresponding, therefore, to a response rate of 76% (GPEARI, 2010). This sample was composed of companies with at least 10 people in the service, and, when a company had 250 or more persons, it was subject to a thorough inquiry. The sample was constructed by the National Institute of Statistics (INE) in accordance with the methodological specifications of EUROSTAT. The sample was stratified by Classification of Economic Activity (CAE) to 2 digits by size (considering the age of persons in the service) and by regional distribution (NUTS II).

Variables

The dependent variable used in this study is the "innovative performance" of the company (DI), following the operationalization of the variables used in the studies conducted by Silva (2003); Escribano *et al.* (2009); Kostopoulos *et al.* (2011) and Berchicci (2013). Innovative performance is measured through a binary variable that examines whether the company introduced innovative products or processes between 2008 and 2010; that is, it is equal to 1 if the company introduced products or processes that are new or significantly improved and 0 if the company did not introduce any type of product or process innovation.

This research uses as independent variables those variables associated with three factors: (i) cooperation in the field of innovation; (ii) absorptive capacity; and (iii) public financial support. The first independent variable used in this research is cooperation in the innovation framework of a company. Cooperation shows the relationships that the company could accomplish with its partners in the field of innovation. In this research, cooperation in the field of innovation is measured through a variable that identifies whether the company, between 2008 and 2010, cooperated with some partners belonging to various sources of information and cooperation. The data are obtained through question 6.1, which asks about the "sources of information and cooperation for the activities of product innovation and process". These variables are measured according to their intensity or importance; therefore, cooperation is measured on a scale from 0 to 3, on which companies classify its importance as: 0 = not used; 1 = low; 2 = average; or 3 = high. This approach has already been adopted in other studies (Escribano *et al.*, 2009; Kostopoulos *et al.*, 2011).

In the empirical research, the ten sources of information and cooperation, presented earlier in Table 1, are grouped into four variables by means of factorial analysis. Thus, the variables tested in the study are internal sources, market sources, institutional sources and other sources. The internal sources are considered to be the internal partners, respectively, within one's own company or the group to which it belongs (SENTG). The sources market is considered to contain external partners, encompassing customers (SCLI), suppliers (SSUP) and competitors (SCOM). The institutional sources include universities and other institutions of higher education (SUNI), consultants, technology centers or other private institutions of I&D (SING) and state laboratories or other public services (SGMT). Other sources include conferences, trade fairs, exhibitions (SCON), scientific journals and technical/professional/commercial publications (SJOU) and professional associations and businesses (SPRO).

Table 1. Sources of information and cooperation for the activities of product and process innovation.

Internal sources	Market sources	Institutional sources	Other sources
• Within the company itself or within the same group	• Suppliers • Clients or consumers • Competitors • Consultants or private companies	• Educational institutions • Public services for R&D	• Conferences and exhibitions • Scientific journals and technical books • Professional associations or business

Source: Own elaboration based on the methodological document CIS 2010.

The existing literature has adopted various ways to measure absorptive capacity, but in any case we can state that there is supremacy in relation to other forms of measurement (Escribano *et al.*, 2009). The following approaches can be used to measure absorptive capacity: (1) quantitative, as referenced by several studies (Cohen and Levinthal, 1990; Tsai, 2001; Cassiman and Veugelers, 2002; Escribano *et al.*, 2009; Kostopoulos *et al.*, 2011); or (2) qualitative, as, for example, used in the study conducted by Lichtenthaler (2009).

Due to the abundance of investigations and the lack of consensus on the method to be used in the measurement of absorptive capacity, this empirical study considers three variables from the data from the CIS 2010: (1) qualifications of human resources in the company (EMPUD), which is measured by question 12.3 – approximate percentage of people with higher education in 2010, represented by seven steps; (2) internal investments in R&D (Intra_cat) – this indicator is obtained by the ratio between the investment and internal R&D expenses and the total amount of investments and expenditure on innovation activities; and (3) foreign investments in R&D (Extra_cat) – this indicator is obtained through the ratio between the investment and R&D expenses and the total amount of investments and expenditure on activities of innovation. For more specific information, these variable ratios are categorical variables of seven levels, corresponding to the seven steps already used by the CIS 2010 to represent the variable qualification of human resources in the company (EMPUD). It should be noted that the calculation of indicators does not completely follow the studies of Escribano *et al.* (2009) and Kostopoulos *et al.* (2011), since it was not possible to obtain the information needed by the GPEARI/MCTES about the number of employees with a degree in business.

Finally, with respect to public financial support, we use a dichotomous variable to identify whether the company benefited from public funding for innovation activities. Thus, it assumes the value "1" in the case of a company that earned public financial support and the value "0" in the opposite case. The same variable was also used in the studies by Silva (2003), Hu and Mathews (2009), Madrid-Guijarro *et al.* (2009) and Silva and Leitão (2009). To measure public financial support, we use the following independent variables: public financial support from the local and regional administration (FUNLOC), public financial support from the central administration (FUNGMT) and public financial support from the European Union (FUNEU).

Method

Given the complexity of the phenomena under study and taking into account that their underlying explanation has a varied set of factors, it is necessary to carry out

modeling of the data and statistical inference. Data modeling aims to provide information about the point estimates of the parameters of the model to gain an understanding of the relationship between the variables as well as information for the hypothesis testing (Gujarati, 2008). In turn, statistical inference corresponds to a technique that allows conclusions to be drawn about the population from the results of the sample (Malhotra and Birks, 2007).

In this follow-up, to achieve the objectives proposed, the study resorted to multivariate statistical analysis, which, according to Hair, Anderson, Tatham and Black (1998); (Hill and Hill, 2009), enables the simultaneous analysis of relations between three or more variables, which may be applied by different statistical techniques, as the relationship in question is dependent or interdependent.

In the present investigation, the dependent variables are dichotomous, and the analysis of dependence can be effected by means of logistic regression. Second, Pestana and Gageiro (2008) presented the most suitable modeling technique to estimate the probability of occurrence of one of the achievements of the classes of variables. Thus, logistic regression is a technique that seeks to understand what distinguishes two groups of cases, that is, what differentiates the two levels of a dependent dichotomous variable.

The theoretical review of the literature performed showed that the innovative performance of an enterprise is a complex phenomenon influenced by a wide range of factors. Therefore, it is necessary to explore the relationship between these factors and the innovative capacity; more specifically, we intend to examine the statistical relationship of a binary dependent variable with more than one explanatory variable, and it is therefore appropriate to use the logistic regression model (logit model). This model has been widely applied in other empirical studies (Conceição and Heitor, 2001; Fritsch and Lukas, 2001; Kaufmann and Tödtling, 2001; Nassimbeni, 2001; Silva, 2003; Silva and Leitão, 2007, 2009; Moreira, 2010; Mention, 2011; Arora *et al.*, 2016; Parrilli and Heras, 2016).

It is also an appropriate method for models that include a categorical dependent variable (binary or dichotomous) and several categorical independent variables (Hair *et al.*, 1998). This binary variable is the propensity for the company to innovate at the product or process level, that is, the propensity for the company to achieve an innovative performance. In this sense, two logistic regression models are estimated, which contain as independent variables those related to the implementation of cooperation, absorptive capacity and public financial support.

Data analysis and discussion of the results

The 3,406 companies selected for this study are subjected to a factorial analysis to group cooperation partners for innovation. This statistical analysis allows the

Table 2. Factorial analysis of cooperation within the framework of the innovation factor for the fields of cooperation.

	Component				
	F1	F2	F3	F4	Commonalities
SGMT (state laboratories, public services)	0.855				0.796
SUNI (universities)	0.836				0.776
SINS (consultants, technology centres, other inst. private R&D)	0.712				0.630
SJOU (scientific journals and technical publications/ professionals/businesses)		0.822			0.793
SCON (conferences, trade fairs, exhibitions)		0.814			0.741
SPRO (professional associations and businesses)		0.690			0.617
SCOM (competitors)			0.837		0.794
SCLI (customers)			0.782		0.721
SSUP (suppliers)			0.438		0.426
SENTG (interns)				0.922	0.901
	Institutional sources	Other sources	Market sources	Internal sources	Total
Percentage variance explained	22.1	21	17.2	11.6	71.9
KMO 0.847					

identification of new variables, called factors, which are fewer in number than the initial set of variables, thus condensing the information contained in the initial variables into a smaller set. Table 2 presents the factorial analysis for cooperation in the field of innovation for the sample.

An analysis of Table 2 enables us to identify four factors, specifically factor 1 (with 22.1% of the explained variance), called institutional sources, which covers the variables state laboratories and public financial support, universities and other academic institutions and even consultants, technology centers and other private R&D institutions; factor 2 (with 21% of the explained variance), called other sources, which includes scientific journals and technical/professional/trade publications, conferences, fairs and exhibitions and professional associations and businesses; factor 3 (with 17.2% of the explained variance), referred to as market sources, which comprises the variables competitors, customers and suppliers; and, finally, factor 4 (with 11.6% of the variance explained), which includes only the

variable relating to internal sources of cooperation. The grouping of the variables obtained through the factorial analysis is in line, in large part, with the grouping underlying the methodological document CIS 2010, systematized in Table 1. The only change is the variable consultants or market undertakings, which was included in the market sources. However, the factorial analysis covers institutional sources in factor 1, which seems to have some logic, because it is known that many services of this nature are obtained interchangeably with institutional sources or consultants/private companies of which the core business is R&D activities. Based on the literature review and the grouping of variables and factors, systematized in the previous table, the logistic regression models for innovation in products and processes are formalized. After the implementation of the logistic regression models for all the observations available, 3,406 companies, the models that are obtained are presented in Table 3.

The results of the logistic regression models for product and process innovation are presented in Table 3. It shows that the predictive ability of the product innovation model is 70.6%, a value that is the result of the comparison between the values of the response variable predicted by the model and the observed values. The chi-square statistic has the value of 357.25, with an evidential value that is below the significance level of 0.05. The log-likelihood statistic, with the value of 3779.20, confirms the overall significance of the model compared with the null model. In turn, the process innovation model presents a predictive capacity of 83.6%, a value that is the result of the comparison between the values of the response variable predicted by the model and the observed values. The chi-square statistic has a value of 355.72, with an evidential value that is below the significance level of 0.05. The log-likelihood statistic, with a value of 298,870, also ratifies the global significance of the model compared with the null model.

Having used the Wald statistic as a test statistic, it is observed that the majority of the estimates of the parameters of the product innovation regression model are statistically significant at the level of 5%, while in the model of product innovation only four are statistically significant. Then an analysis of the estimates of the models is performed and, at the same time, the research hypotheses are tested.

The first hypothesis argues that the propensity of a company to innovate is related to the implementation of cooperation with partners belonging to its internal sources – H1.1. The results show that the cooperation undertaken with partners from internal sources of information, that is, from the company itself or the group to which it belongs, has a positive and significant effect on innovation, both product and process. These facts are proved by the result of the estimation of the associated parameters (0.199 and 0.101) as well as by the analysis of why an advantage is associated with the variable: 1.221 for product innovation and 1.107 for process innovation. In this way, an increase in cooperation with partners inside

Table 3. Logistic regression model of the determinants of product and process innovation.

	Product innovation				Process innovation			
	B	S.E.	Sig.	Exp (B)	B	S.E.	Sig.	Exp(B)
Cooperation for innovation								
Internal sources	0.199	0.041	0.000*	1.221	0.101	0.049	0.037*	1.107
Market sources	0.235	0.039	0.000*	1.265	0.049	0.046	0.290	1.050
Institutional sources	−0.056	0.043	0.197	0.946	0.006	0.052	0.906	1.006
Other sources	0.158	0.040	0.000*	1.171	0.122	0.047	0.010*	1.130
Absorptive capacity								
Qualification of personnel	0.024	0.025	0.344	1.024	0.031	0.029	0.293	0.970
Internal invest. in R&D	0.166	0.016	0.000*	1.181	0.026	0.018	0.150	1.027
External invest. in R&D	0.078	0.019	0.000*	1.081	0.083	0.024	0.001*	1.086
Public financial support								
PFS from local and regional administ **(FUNLOC)**	0.209	0.262	0.425	1.232	0.036	0.311	0.907	1.037
PFS from central administ **(FUNGMT)**	0.335	0.107	0.002*	1.398	0.359	0.130	0.006*	1.431
PFS from the European Union **(FUNEU)**	0.108	0.160	0.500	1.114	0.296	0.199	0.137	1.345
Constant	0.295	0.081	0.000*	1.343	1.471	0.098	0.000*	4.354
Quality of adjustment of the model								
Predicted correctly (%)		70.6%			83.6%			
Chi square		357.25	0.000		355.72	0.000		
Log likelihood		3799.20			2988.70			
Number of cases		3 406			3 406			

AQ: Kindly provide Table 4 citation in text.

Table 4. Summary of the outcome of the hypotheses.

Cooperation for innovation	Product innovation	Process innovation
Internal sources	✓	✓
Market sources	✓	
Institutional sources		
Other sources	✓	✓
Absorptive capacity		
Qualifications of personnel		
Internal investments in R&D	✓	
External investments in R&D	✓	✓
Public financial support		
PFS from the local and regional administration (FUNLOC)		
PFS from the central administration (FUNGMT)	✓	✓
PFS from the European Union (FUNEU)		

the company also increases the propensity of the company to innovate in products and in processes, showing an advantage of 1.221 and 1.107, respectively, compared with companies that do not cooperate with this type of partners. The results corroborate the study by Evangelista (2006), which shows that companies rely on internal sources of information.

As regards the second hypothesis, it is intended to test whether the implementation of cooperation with partners belonging to the market sources is associated with the propensity for a company to innovate – H1.2: The realization of cooperation with partners belonging to the sources of the market is positively associated with the propensity to innovate. In relation to the propensity to innovate in processes, nothing can be concluded about the effect of this factor, given that the results obtained show that the achievement of cooperation with partners belonging to the market sources has no statistical significance in the model of process innovation.

Concerning the model of product innovation, the results show that the achievement of cooperation with partners belonging to the market sources has a positive and significant effect on the propensity to innovate at the level of products. Thus, the greater the intensity of cooperation with these partners, the greater the propensity of the company to innovate in products. The ratio of the associated advantage is 1.265 compared with companies that do not cooperate, so we can reject the null hypothesis of the non-existence of a relationship between the variables considered. In this way, hypothesis H1.2 confirms this model at the level of the propensity to innovate in products. It is also worth noting that the cooperation undertaken by the partners of the sources of information from the market,

in particular customers, suppliers or consumers, positively influences product innovation, thus reinforcing the results of the study by Tether (2005). The results obtained from research conducted in Canada (Baldwin *et al.*, 1998) also emphasized the importance of these external sources as influential factors in the propensity to innovate.

The third hypothesis associates the propensity of a company to innovate with the realization of cooperation with partners belonging to institutional sources – H1.3. This is not statistically significant. The results show that the variable implementation of cooperation with this type of partners has no statistical significance in the models of innovation for products and processes; therefore, nothing can be concluded about the effect of this factor on innovation performance.

The fourth hypothesis establishes the relationship between the propensity to innovate and established cooperation with partners from other sources – H1.4: The realization of cooperation with partners belonging to other sources is positively associated with the propensity to innovate. The cooperation undertaken with partners from other sources of information, particularly those from scientific journals and technical publications/professionals/businesses, conferences, trade fairs and exhibitions, professional associations and business consultants, positively influences the propensity for the company to innovate at the level of products and processes. These facts are associated with the result of the ad hoc estimation of parameters (0.158; 0.122) as well as that of the analysis of why an advantage is associated with the variable (1.171; 1.130). Thus, depending on whether there is an increase in cooperation with partners from other sources, it also increases the propensity for the company to innovate in products and processes, showing an advantage compared with companies that do not cooperate with this type of partners. Mothe and Nguyen (2008) also obtained results that confirm the importance of consultants, laboratories or private R&D institutions as fundamental sources that contribute to the propensity to innovate.

The fifth hypothesis to be tested associates the propensity of a company to innovate with the qualifications of its personnel – H2.1: The qualifications of a company's human resources are positively associated with its propensity to innovate. The results show that the variable qualification of human resources has no statistical significance in the models of innovation in products and processes, so no conclusions can be reached about the effect of this factor on innovation performance.

The sixth hypothesis is formulated as follows – H2.2: An increase in the proportion of internal investments in R&D is positively associated with a company's propensity to innovate. In relation to the model of process innovation, nothing can be concluded about this variable, since it has no statistical significance. However, it is noted that companies that make this type of investment have

a higher propensity to innovate at the level of products, evidencing an advantage of 1.181 compared with companies that do not perform internal investments in R&D, thus corroborating the results of the study by Silva *et al.* (2010). Given these results, it is notable that the greater the achievement of internal investments in R&D in larger enterprises, the higher the propensity to innovate at the product level. Thus, we can reject the null hypothesis of the non-existence of a relationship between the variables; therefore, hypothesis H2.2 is accepted in this model.

The seventh hypothesis formulated is designated H2.3: An increase in the proportion of foreign investments in R&D is positively associated with a company's propensity to innovate. The results show that external investments in R&D have a positive and significant effect on the propensity to innovate of a company, at both the product and the process level, proving these facts by examining the ratio of advantage (1.081) and (1.086), respectively, and reinforcing the results of the study by Paranhos and Hasenclever (2011), which shows that innovative companies invest in R&D. The study by Boone (2000) also shows that companies that acquire R&D more efficiently are more innovative.

The eighth hypothesis to be tested is formulated in the following way – H3.1: Public financial support from the local/regional administration is positively associated with a company's propensity to innovate. The results show that this variable is not statistically significant in the models of product and process innovation, so no conclusions can be reached about the effect of this factor on innovation performance.

The ninth hypothesis establishes the relationship between the propensity of a company to innovate with PFS from the central administration – H3.2: Public financial support from the central administration is positively associated with a company's propensity to innovate. It is found that this variable has a positive and significant effect on the propensity to innovate in products and in processes, proving these facts through an analysis of the point estimation of the associated parameters and the reason for an advantage associated with the variables of 1.398 and 1.431, corresponding, respectively, to the models of product and process innovation. These results are corroborated by studies that relate to public financial support appearing as a determinant factor in the promotion of innovation activities (Tourigny and Le, 2004; Silva *et al.*, 2009; Moreira, 2010; Silva *et al.*, 2012).

The last hypothesis to be tested, it is formulated in the following way – H3.3: The company that benefits from public financial support from the European Union is positively associated with the propensity for the company to innovate. The results show that this variable is not statistically significant in models of innovation in product and process, so nothing can be concluded about the effect of this factor in innovative performance.

The following table summarizes the hypotheses for which it was possible to reject the null hypothesis of non-existence of a relationship between each of the variables with the innovative performance of the company, therefore confirming the hypotheses associated with all the variables indicated.

Conclusion

This research aimed to analyze the determinants of innovation that influence the innovative process in Portuguese companies and consequently their innovative performance at the level of product and process innovation. The determining factors referred to here are not exhaustive; however, in this study, we highlight cooperation, absorptive capacity and public financial support.

In accordance with the objective of this research, hypotheses were formulated and tested using logistic regression models, after having extracted the factors that formed the variables of cooperation through a factorial analysis.

Based on the sample of 3406 companies, the total number of valid cases for which information was available about the set of independent variables in this study, most were of a small size (50.7% of the total sample), and a significant number (50.4% of the total sample) have low-skilled human resources and even resources without any qualifications (10.2% of the total sample). Few companies have resorted to public financial support (PFS). Those that have resorted to public financial support from local/regional innovation activities are almost negligible (2.5%) compared with those that have appealed to the central administration (23.4%) and even the EU (9.2%). In the global statement, nevertheless, the demand for the PFS referred to remains low. The analysis of Table 3 also indicated that more businesses innovate in processes (2,846) than in products (2,387).

The results obtained in the model confirm that the implementation of cooperation with partners belonging to internal sources of business has a significant influence on the innovations made both at the level of products and at the level of processes. According to the theoretical framework, the implementation of cooperation with partners belonging to the company's internal sources is basic and necessary for innovative performance at the level of both products and processes; that is, cooperation of this type has a positive influence on the design and development of new products or significant improvements in existing products as well as the implementation of new processes, such as cooperation with partners belonging to other sources. Companies that innovate through cooperation are therefore more prone to develop innovations at the level of products and processes than those that do not cooperate. As regards the effects of cooperation with partners belonging to the sources of the market, in particular established

relationships with customers, suppliers and competitors, it is noted that these companies have a higher propensity to innovate in the accompanying products, possibly because of the changes in perceptions and needs of customers, as well as the evolution of market trends.

Regarding the purpose of the relation between innovative performance and internal investments in R&D, it is noted that the implementation of this type of investment in R&D is positively associated with the propensity for a company to innovate at the product level. In relation to the realization of foreign investments in R&D, it appears that companies that make foreign investments in R&D have advantages in developing innovations at the product and the process level compared with companies that do not perform this type of investment.

Based on the hypotheses tested, the results of the model suggest that PFS from the central administration has a positive and significant effect on innovation at the level of products and processes. The results suggest that companies that benefit from this type of PFS are more prone to develop innovations in both than those that do not benefit.

The results obtained suggest that new measures of orientation of public policies aimed at businesses, especially micro and SMEs, which constitute the greater part of the Portuguese business fabric, enable them to access innovation. In this way, the determinant factors of innovation, analyzed in this chapter, may make a greater contribution to the innovative performance of Portuguese companies not only through the enhancement and upgrading of human resources, such as the protection of knowledge, but also through the encouragement of cooperation supported by networks and better availability of PFS, based on the implementation and/or development of innovation systems.

The secondary data that we had access through a survey Community Innovation Survey (CIS 2010) in Portugal, made available by INE (National Institute of Statistics), proved to be insufficient for the construction of some variables. This limitation of data, due to CIS 2010, made it impossible to use several variables, such as the proxy for innovation, like the share of sales from innovative products, among other proxy and, consequently, the respective enrichment of the empirical analysis

As a research proposal for future work, we suggest that re-orientate the analysis to that of the LMT firms and SME perspective, following the trajectory of researchers such as Hirsch-Kreinsen and Jacobson (2008) this would make it possible very rich analysis. It is also suggested the empirical research applied to data from the CIS (2012, 2014), so as to enrich and complement the work undertaken and allow an analysis of innovation in product and process a broader horizon, or, still, repeat the research, based on only those data, thus obtaining the most updated information, allowing the evaluation of evolutionary trends of

innovation and the consequent impact of the determinant factors of innovation on the innovative performance of Portuguese companies, the level of product and process.

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