Incentives and inhibiting factors of eco-innovation in the Spanish firms.

Abstract

This paper investigates the incentives and inhibiting factors of eco-innovation capacities in the firm. Firms materialize the objectives of eco-innovation from a reactive attitude to external pressures, to a more proactive attitude that implies the voluntary incorporation of eco-innovation activities. This variability in the behaviour of companies with respect to the level of eco-innovation development has been a motivator for the research. However, despite the importance of this research question, this has been approached in a dispersed way from multiple approaches. From a dynamic capabilities perspective, we assume that the innovation capacity of the firm encourages eco-innovations. Our paper is focused on the process of eco-innovation, identifying the elements that facilitate or hinder the eco-innovation in the firm. We study the Spanish case, using a panel from the Spanish Innovation Survey, with a sample of 5,461 Spanish firms. The results highlight that the complexity of the eco-innovation process negatively affects the decision to develop eco-innovations. However, our results suggest that institutions and organizations of the Spanish environment are making efforts to compensate these obstacles and provide incentives to develop eco-innovations.

1. Introduction

Over lasts years, eco-innovation has been considered a driver of economic development (Constantini et al., 2017; Arena et al., 2017). This is the case, for example, of the use of biochar, aimed at revitalizing degraded soils, improving soil carbon sequestration, and increasing agronomic productivity (Spokas et al., 2012); the development of renewable energies as an alternative to fossil fuels (Ellabban et al., 2014); or the introduction of waste management, aimed at optimizing processes and their economic profitability (Maroušek, 2014). In this context, several studies highlight the relation between eco-innovation and firms, emphasizing the role of firms in the development of eco-innovation (Doran and Ryan, 2016; Liao, 2018a). Thus, the growth of demand for environmental improvement and the importance of sustainable development in the society has increased the number of techniques, products and services respectful with the environment. Vellinga and Herb (1999), and Jové-Llopis and Segarra-Blasco (2018) conclude that in the context of *industrial transformation*,

which implies changes in production and necessary patterns on the path to sustainable development, firms must play an active role.

Firms materialize the objectives of eco-innovation in the selection of activities and the degree to which they are developed (Doran and Ryan, 2016; Liao, 2018b). In this context, firms set objectives from a reactive attitude to external pressures, to a more proactive one that implies the voluntary incorporation of eco-innovation activities (Doran and Ryan, 2016; Jové-Llopis, and Segarra-Blasco, 2018). Thus, there is variability in the scope and depth of eco-innovation objectives. These include the compliance with legislation, such as for example the development of eco-innovations that aim at controlling waste (discharge and high toxicity emissions) and compliance with environmental standards; the implementation of environmental quality systems, for example the ISO 9001, 14001 and Integrated Management Systems (ISO, 2019); the creation of ecological products for new markets, including the application of Directive 2009/125/EC for the establishment of eco-design requirements for energy-related products (Bovea and Pérez-Belis, 2012); and finally, industrial symbiosis, in the context of circular economy (Lieder and Rashid, 2016; Baldassarre et al., 2019). This variability in the degree of firms' development of eco-innovation has been a motivation for research to recognise the main drivers of environmental innovation in the company (Cuerva et al., 2014; Horbach et al., 2012). Most researchers have concentrated on the effect that policies and regulations have on the eco-innovation in the firm (Novellie et al., 2016; Liao, 2018a). Also, although in a dispersed manner, studies on eco-innovation have also emerged from the field of industrial organization (Triguero et al., 2013; Peiró-Signes and Segarra-Oña, 2018), understanding the external drivers of environmental innovation (Bossle et al., 2016). More recently, the decision-making literature has advanced towards the understanding of internal factors to the company for the decision to develop eco-innovation. Marousek (2013), in the study of the use of renewable energies in agriculture, points out how ethical, energy and financial factors affect the decision to adopt eco-innovation objectives. Govindan et al. (2015) analyse the factors that affect the decision process of the evaluation and selection of green suppliers. Studying the development of biochar, Marousek et al. (2015) conclude that the decision to eco-innovate is a combination of social responsibility, risk, and experience. However, despite these efforts, few studies emphasize the innovation capabilities of the company as a driver in the development of eco-innovation. Horbach et al. (2012) point out that it is necessary to continue investigating what factors motivate or hinder firms to develop eco-innovation to get a complete overview of the determinants of eco-innovation in the firm.

Our study uses the dynamic capabilities theoretical approach to explore firms' eco-innovation development. Following this approach, we assume that the innovation capacities of the firm encourage eco-innovations. Our work puts the emphasis on the process of eco-innovation, identifying the elements that facilitate or hinder eco-innovation in the firm (Wicki and Hansen, 2017; Tang et al., 2018). Companies develop eco-innovation in a dynamic process of interaction of skills, abilities, routines and resources (Teece, 2007). We assume that this process is conditioned by the capacities that the firm has on that process, which is based on the factors that facilitate or hinder the development of innovation. Therefore, we consider that firms' decision to adopt eco-innovation objectives will be the result of the ease or difficulty in performing the process, as a consequence of the factors that facilitate or inhibit eco-innovation. Our research question is focused *on identifying the factors that facilitate or hinder eco-innovation in the firm.*

We test the research question using a panel data from the Spanish Innovation Survey (PITEC, 2013), with 5,461 Spanish firms. We study, firstly, how the management of the eco-innovation process affects companies' decision to adopt eco-innovation. Thus, the uncertainties derived from the process, the market, and the management of the eco-innovation, are the main factors to be analysed. Secondly, we study how different policies and actions in the firms' environment are affecting firms' eco-innovation objectives. Thus, we analyse facilitating elements such as the availability of the information sources, the existence of means to establish cooperation agreements, and the availability of public financing.

This research contributes to the eco-innovation literature with new empirical knowledge. We provide empirical evidence to understand what elements affect the proactivity of the firm in the development of environmental actions. Our work complements previous literature (Da Silva et al., 2017; Doran and Ryan, 2016) by highlighting that the control of the eco-innovation process, affected by factors that facilitate or hinder environmental innovations, is another element to be considered in firms' eco-innovation objectives.

2. Materials and Methods

To explore our research question, the factors that facilitate or hinder eco-innovation capacities in the firm, we first present the conceptual framework and the model of our research, generating the hypotheses; second, we describe the research methodology, including data collection, measures and the econometric model.

2.1. Conceptual Framework and Model

Our paper is framed in the dynamic capabilities theory (Teece, 2007). Teece et al. (1997: 516) considered the dynamic capabilities as "*the firm's ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments*". Thus, the dynamic capabilities are presented as specific and identifiable processes, considered the dynamic capabilities as foreseeable behavioural patterns, through which the organisation manages its resource, with the objective of obtaining the success of the company (Eisenhardt, & Martin, 2000). Therefore, dynamic capabilities encompass the management of capabilities and resources of all functions of firms, with the final objective to develop innovations.

In our research, the model involves the eco-innovation developing processes and the impact on firms' decision (Figure 1). The model postulates that the eco-innovation entails the development of a dynamic process of capabilities, routines and resources that are influenced by the firms' degree of control, as consequence of the hindering or facilitating factors found in the process. Therefore, firms' decision to develop eco-innovation depends on the difficulty or perceived facilitate of performing this type of innovation.

Hindering Factors: the complexity of the eco-innovation process.

The innovation development process has been characterized as a complex process from the managerial point of view (De Medeiros et al., 2018; Arranz and Fernandez de Arroyabe, 2009). In this sense, the uncertainty of the process itself and the market, as well as the management of firms' resources and cooperation agreements for the eco-innovation, are a set of difficulties and obstacles that must be overcome in this process (Arranz and Fernandez de Arroyabe, 2006; Lundwall, 2007).

The first group of obstacles arises from the *uncertainty of the process*. Uncertainties of innovation outcomes, as well as the time invested in its realization, are sources of difficulties for firms to develop innovation (Tidd et al., 2005). The firm perceives that this uncertainty in the development of innovations could suppose a deviation in the budget, as a result of not achieving the technical solutions sought, therefore, more resources and/or more time than the expected need to be allocated. Lee and Park (2006) point out that this extra cost implies an added problem for the company. It is necessary to finance this extra cost and search for financing, which supposes an additional difficulty to the management of the innovation process, considering that the limited resources are allocated to the firm (Lee and Park, 2006; Lundwall, 2007). Therefore, the management of costs and financing of the development of eco-innovation will have a negative effect on firms' objectives to develop green innovation.

The second group of obstacles arises from the *complexity of managing the eco-innovation process*. Arranz and Arroyabe (2009) point out that the innovation process involves the development of exploration and exploitation tasks in the firm. First, exploration requires experimenting and searching for activities to find new and emerging innovations capable of generating future sources of profits (Gilsing et al., 2008). Gilsing et al. (2008) point out that firms need to develop management systems for the acquisition of novel information on markets and technologies. Second, exploitation implies the extension and refinement of existing technologies, paradigms and competencies (Rothaermel and Deeds, 2004). In this case, the company must manage an adequate staff, with a level of competence appropriate to the needs of exploitation. The management of exploration and exploitation in the firm has been highlighted as difficult activities to combine. Thus, O'Reilly and Tushman (2004) noted that this involves managing different organizational and strategic requirements, generating tensions in the firm. These authors also argued that both orientations compete for the scarce resources of companies, which generates the need to manage the exchanges between the two in an adequate balance (O'Reilly and Tushman, 2004). Otherwise, the development of innovation is currently assumed in the literature to be a cooperative process with other organisations. However, Hagedoorn et al. (2006), and shows that the development of cooperation agreements implies several obstacles, for example, the necessary coordination of two or more partners, the discrepancies in the goals and cultural differences, and the problems derived of the relation among partners. In this sense, Hagedoorn et al. (2006) highlight that is important to search for suitable partners with the aim of mitigating the subsequent problems of the management of cooperation agreements. Therefore, as a consequence of the need to generate information, capabilities in the firm, and management of the search for partners, the management of the eco-innovation process, will have a negative impact on firms' objectives.

Finally, another group of obstacles that firms usually find in the development of innovations are those derived from the *uncertainty of the market*. Hagedoorn (2006) pointed out that uncertainty occurs in the face of ignorance of the consumer reaction to the innovative product. An example this is the ecological products in the agro-food sector, where the ecological product has an extra-cost compared to the similar non-ecological product (De Medeiros et al., 2018). In this case, the consumer will be willing to pay more if his perception of the relation quality-cost is acceptable. Although it is observed that there is an increase in the intangible value of the products (Sala et al., 2017; Mirata and Emtairah, 2005), the additional cost generates uncertainty in the firm, which implies the development of additional

actions to achieve the acceptance of the product in the market (Rehfeld et al., 2007). This situation becomes more complicated if the market is dominated by established firms, which creates an added difficulty to the entry of new products/firms (Theyel, 2006). On the other hand, derived from the double effect of eco-innovation, the ecological advantages usually disappear as a consequence of the disincentive that exists to develop ecological research. Choi et al. (2016) point out that due to the fact that environmental knowledge has public good characteristics, it is relatively easy to copy the first innovators without assuming the research costs and risks. Therefore, the management of the eco-innovation process, as a consequence of the uncertainty of the market, will have a negative impact on firms' objectives.

External facilitating factors in the eco-innovation objectives.

By the mere fact of belonging to a geographical area, the companies are exposed to institutional elements that encourage the adoption and development of innovations. We assume, following Gilsing et al. (2008), that companies do not innovate alone: innovation is an interactive process of the different actors and institutions that participate in the innovation system. Thus, National Innovation Systems (NIS) have emerged as focal points for innovation and technology, as well as for facilitating the relationship and interaction between private companies, researchers and institutional actors (Lundvall, 2007; Wicki and Hansen, 2017). The interactions allow the sharing of risks and resources, reducing the times to develop innovations, and increasing the access to knowledge, and markets (Parida et al., 2014), which facilitate innovation development. To understand the dynamics of the innovation system, following Wicki and Hansen (2017, page 1121), we must identify the structural elements that have a positive influence on the process of innovation development. On the contrary, negative self-reinforcing dynamics can also appear when several factors are accumulated that prevent the system from favouring innovative dynamics (Wicki and Hansen, 2017). Therefore, the identification of these factors and their impact is a key element to promote an innovative system.

A first factor considered in the research of innovation is the readiness of *information* that the firm has in its environment. Carrion-Flores and Innes (2010) show that the information sources positively impact on the adoption of eco-innovation objectives. Amores-Salvado et al. (2015) highlight that information is a key element for the environmental management in firms. In this line, Rogers (2003: 172) considers that the decision to implement innovations is a process as "*an information-seeking and information-processing activity*". The firm becomes aware of the necessity of developing eco-innovation, evaluating the feasibility of this development (Rogers 2003). In this context, the environment in which the firm operates

enables a continuous flow of information and knowledge exchange between actors on market, and eco-innovative possibilities (Wang et al., 2012). This information may come from the market, different institutions, trade fairs, seminars, and journals, among others (PITEC, 2013). Consequently, the eco-innovation decision might be affected, for example, by information about the existence of new regulations and certifications, new environmental technologies, or new market necessities. Therefore, information is an incentive for the firms, which will impact positively on the development of the eco-innovations.

A second factor is the establishment of *collaboration agreements* with other companies, organizations or institutions. Gilsing et al. (2008) point out that one of the ways of accessing the experience and knowledge acquired by other firms in their innovation activities is by establishing cooperation agreements with them. Thus, the development of cooperation agreements allows sharing the risks of innovative development (Hagedoorn et al., 2006). In this sense, and drawing parallelism with other types of innovation, it is that these cooperation agreements will positively influence the adoption of eco-innovations (Cuerva et al., 2014). For example, the cooperation with clients allows the development of new ecological products (Kemp et al., 2006). Additionally, the agreements of cooperation with suppliers permit the incorporation and development of innovations in energy saving or the reduction of waste and pollution (MIrata and Emtairah, 2005). In this line, De Marchi (2012) points out that the cooperation with suppliers enables eco-innovation, highlighting this effect as compared to other types of innovation. Finally, cooperation with universities has been considered a source of low-cost innovation (Koontz et al., 2015 Aragón-Correa). Therefore, cooperation agreements allow companies to generate a stock of shared knowledge, and risk sharing, having a favourable impact on firms' decision on eco-innovations development.

Finally, *financial facilitators* have been used to incentivize innovation in enterprises (Da Silva et al., 2017; Choi et al., 2016). As seen previously, the innovative development requires firms to have adequate financial resources to develop this process. In this context, the various institutions, whether local, national or international, develop financing facilities for innovations and eco-innovation, encouraging the incorporation of environmental objectives in the firm (Doran and Ryan, 2016; Horbach, 2008). Therefore, financial incentives in the process to develop eco-innovations will have a favourable impact on companies' objectives for eco-innovations development.

In Table 1b, we show the generated Hypotheses.

2.2. Research Methodology

2.2.1. Context: Spain and the development of eco-innovation

The report of environmental innovation of the European Union points out that Spain appears in the 9th position in the Eco-Innovation Index performance ranking of the EU27 (Eco-Innovation Observatory, 2018). Following this report, the most important areas of eco-innovation in Spain include '*eco-design, ecological engineering, energy efficiency, sustainable construction, urban greening systems, urban water systems and the efficiency of water*' (Eco-Innovation Observatory, 2018, p. 53). However, Spain is below the European average in terms of the environmental products generated and the inputs for eco-innovation. The Eco-Innovation Observatory (2018) points out that the main weaknesses and barriers to ecological innovation in Spain are: the generation of organic products by companies, the deficiency of public support for developing eco-innovation and the emigration of qualified human capital.

2.2.2. Data collection

In this research, firm-level data is collected from the Spanish Technological Innovation Panel (PITEC). This database has been developed by the National Statistics Institute and replicates the questionnaire of the Community Innovation Survey, using a standardised questionnaire (OECD, 2009). This database has been widely used for innovation studies at the firm level, and more specifically for eco-innovation studies in Spain (for example, Cainelli et al., 2015). Likewise, the same questionnaire has been used as well in other European countries for eco-innovations studies (for example, Wagner, 2007).

PITEC is a database, which collects biannually all the innovation data of Spanish companies since 2001. PITEC contains firm-level data and it provides information about the company (employment, sales, geographic market, industry sector, etc.) as well as detailed information regarding its innovation activity (innovation expenditures, different kinds of innovation output, cooperation between firms, public financial support, barriers to innovation, and so on)[1].

The population framework of PITEC is the Central Directory of Spanish Companies (DIRCE), which includes Spanish companies located in the national territory. PITEC has a sectoral coverage of agricultural, industrial, construction and service companies, following the NACE-2009 classification. From the geographical scope, the survey covers the whole of the national territory. The information collection method is a mixed system that includes

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[1] More in detail, the PITEC questionnaire, containing 567 variables, is structured in the following sections: General data of the company; internal R&D activities of the company; Purchase of R&D services; Innovation activities carried out by the company; Innovation of products and processes; factors that hinder innovation activities in the company; intellectual and industrial property rights; Non-technological innovations The questions are measures with a combination of the scale, dummy, Likert and continuous.

sending emails, interviews, with telephone support in the collection of the information, taking place in four months[2].

The reference period for our study is 2010-2012. We proceeded to filter the sample, removing those firms for which the data of any of the years 2010-2012 was missing. In addition, we dropped micro-firms (<10 employees), and firms involved in mergers and acquisitions. After a filtering process, our final sample is a balanced panel containing 5,461 firms, from which 3,462 firms have conducted some sort of eco-innovation over the period of study.

2.2.3. Measures

Measure of eco-innovations (see Table 2). The questionnaire from PITEC measures the environmental innovation with the following question: has the innovative activity carried out in your company oriented towards the following environmental objectives: i) Less energy per production; ii) Lower environmental impact; iii) Improvement in health and safety; and iv) Compliance with regulatory, environmental, health, or safety requirements. The environmental innovations are rated on a scale of 1 to 4: a value of 1 is assigned if the degree of orientation is high; 2 if it is intermediate; 3 if it is low; and 4 if it is null.

Hindering factors in the innovation process (see Table 2). The PITEC questionnaire measures the importance of various hindering factors for innovation activities, classifying it into three types of obstacles.

- The first group of obstacles refers to the costs and financing of the companies of the innovation process, which is measured with three items: i) Lack of funds in the firm or group of firms; ii) Lack of funding from sources outside the company; iii) Innovation's high cost (Cronbach's Alpha: 0.778). The value of 0.778 of the Cronbach's Alpha, shows that the three variables are correlated[3]. Therefore, we create a new variable, *Cost and Finance Obstacles*, which brings together the three variables using Principal Component Analysis. The new variable explains 68.320% of the variance, with acceptable reliability as shown by the KMO= .624[4] and significant (sig. = 0.000).

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[2]PITEC sampling errors: Coefficient of variation of expenditure on innovation: 0.35%. Coefficient of variation in the number of innovative companies: 1.38%. Coefficient of variation in the number of innovative technology companies: 1.76%. Coefficient of variation in the number of innovative non-technological companies: 1.57%.

[3] Cronbach's alpha is a test used to estimate the reliability, or internal consistency, of a composite score, showing the level of correlation between more than two variables. In the literature, values higher than 0.600 are considered acceptable.

[4] The Kaiser-Meyer-Olkin (KMO) test takes values between 1, meaning that the new variable explains and perfectly adjust to the initial variables, and 0, where the new variable the construct does not explain the model. In the literature values greater than 0.500 are allowed.

- The second group of obstacles, in PITEC questionnaire, corresponds to the management of the innovation process. In this case, there are four items: i) Lack of information on technology; ii) Lack of information about the markets; iii) Lack of qualified personnel; iv) Difficulties in finding cooperation partners for innovation (Cronbach's Alpha: 0.752). The four variables are correlated and, therefore, we create a new variable (*Innovation Process Obstacles*) using Principal Components Analysis. The factor obtained explains 69.002% of the variance, with acceptable reliability as shown by its KMO = .675 and sig. = 0.000.

- Finally, the market obstacles that influence the development of the innovation is measured are measured with two items: i) Uncertainty regarding the demand for innovative goods and services; ii) Market dominated by established firms (Cronbach Alpha: 0.930). Also, we develop a new variable (*Market Uncertainty*), which explain the 81.559% of variance, and a reliability test (KMO= .811>0.500, sig.= 0.000).

External facilitating factors in the innovation objectives (see Table 2). Regarding the external facilitating factors of the innovation process, we use the next variables from PITEC questionnaire.

- The first variable used is the *Information Sources*. The questionnaire considers both the intensity and the diversity of the sources of information consulted. The intensity of the use of sources is rated on a scale of 1 to 4: a value of 1 is assigned if the degree of utilisation is high; 2 if it is intermediate; 3 if it is low; and 4 if it is null. The diversity of the sources distinguishes between ten different external sources: i) Suppliers; ii) Customers; iii) Competitors; iv) Consultants and commercial laboratories; v) Universities; vi) Public research bodies; vii) Technology centres; viii) Conferences, trade fairs and exhibitions; ix) Scientific journals; x) Professional and industry associations (Cronbach's Alpha: 0.979). The new variable explain the 87.014 % of variance, with and reliability acceptable (KMO= .893, sig. = 0.000).

- The second external factor is the *Cooperation for Innovation,* which is a dummy variable, being 1 if the company cooperate, and 0 if it does not.

- The third variable is the support of external *Public Funding* to the innovation processes, which has been measured with three items: i) From local or regional governments; ii) From the national government; iii) From the European Union.

Control variables

Testing the hypotheses required that we control for the possible effects of other variables to account for relevant effects that could influence the impact of the variables, and to provide new empirical evidence. The control variables used are:

- Previous empirical studies have found firms' size to be an important element in the developing of new technological innovations (Damanpour and Schneider, 2006). *Firm size* is measured with the log of the number of staff in the firm (*Firm Size*).

- The second control variable measures whether firms belong to the manufacturing or services sector, is a dummy variable (*Manufacturing/Services*), being 0 if the company belongs to the manufacturing sector and 1 if it belongs to the service sector.

- A common variable in studies on innovation is the inclusion of a variable that records whether the firm is part of a group (*Group*), being 1 it the company belongs, and 0 if it does not.

- The final control variable is the international scope of the firm. PITEC questionnaire distinguishes four different geographical areas. We include a variable to control where the firm is operating: 0 if it is in the local or national market, 1 if is in the EU exclusively, and 2 if it operates in the US and other countries (*International Market*).

2.2.4. Econometric model

To test the first group of hypotheses that explore the impact of obstacles on the eco-innovation objectives in the firm, we use an Ordinal Logit Regression Model (see Table 4b). Based on the questionnaire, we use four different specifications to analyse the effect of obstacles on eco-innovation. Models 1 to 4 have as dependent variables the four different types of eco-innovations (*Less Energy; Lower Impact; Improvement Health and Safety; Regulatory Requirements*). Moreover, Model 5 uses the encompassing variable *Eco-innovation* as the dependent variable. This variable measures the degree of penetration of environmental objectives in the firm, and this is getting as the sum of the four eco-innovations. As independent variables for the five models, we include obstacles factors (*Cost and Finance; Innovation Process; Market Uncertainty)*, and four control variables.

Our econometric model is (Models 1 to 5, Table 4b):

y=constant + β_1(Cost and Finance) + β_2(Innovation Process) + β_3(Market Uncertainty) + β_4(size) + β_5(manufacturing/services) + β_6(group) + β_7(International Market) + e

being:

y: depend variable (*Less Energy; Lower Impact; Improvement Health and Safety; Regulatory Requirements; Eco-innovations*).

β_i: Regression Coefficient.

e: error terminus.

Models 6 to 10 in Table 5b explore the impact of facilitating factors on the eco-innovation objectives in the firm. Using Ordinal Logit Regression, Models 6 to 10 have as dependent variables the four different types of environmental objectives and, similarly Table 4b (Model 5), Model 10 has as dependent variable the environmental objectives. As explanatory variables, we include facilitating factors (*Information Sources, Cooperation for Innovation, Public Funding: Local or Regional, National, and European Union*) and four control variables.

The econometric model is (Models 6 to 10, Table 5b):

$y = constant + ß_1(Information\ Sources) + ß_2(Cooperation\ for\ Innovation) + ß_3(Local\ or\ Regional) + ß_4(National) + ß_5(European\ Union) + ß_6(size) + ß_7(manufacturing/services) + ß_8(group) + ß_9(International\ Market) + e$

being:

y: depend variable (*Less Energy; Lower Impact; Improvement Health and Safety; Regulatory Requirements; Eco-innovations*).

$ß_i$: Regression Coefficient.

e: error terminus.

3. Results and Discussion

Table 3 shows the descriptive results of the variables analysed. We note that 3,462 firms, six out of ten of the sample (63.3%), claim to have at least one eco-innovation objective. Our data highlights that the percentage of companies that develop eco-innovation in the manufacturing sector is greater (70.1%) than in the service sector (61.7%). Moreover, firms that declare a greater degree of internationalization in their activities assume eco-innovation objectives more frequently (67.7%). In addition, 67.6% of the firms that belong to a group are carrying out eco-innovation activities. Regarding the impact of firms' size in the realization of eco-innovation, it is observed that between 60 and 70% of SMEs and large firms assume eco-innovation objectives. Finally, it is noted that 100% of the firms that establish cooperation agreements to develop innovations declare to carry out at least one eco-innovation activity. Likewise, firms that have developed at least one environmental innovation objective use external sources of information or have a R&D department for innovations.

Table 4b shows the factors that hinder the eco-innovation process in the firm. Regarding Hypothesis 1a, in Model 5, we observe that the costs and financing of the innovation process (*Costs and Finance*) have a negative and significant impact (ß = -0.554, p <0.01) on the eco-

innovation. These results corroborate our hypothesis, showing that lack of funds both internal and external to the firm, as well as the high cost of innovation, are obstacles in the development of eco-innovations. In reference to Hypothesis 1b, the results of Model 5 highlight that the management of the innovation process (*Innovation Process*) is a variable that has a negative impact ($ß = -0.449$, $p < 0.01$) on the adoption of eco-innovations, supporting the hypothesis that the difficulties of the process, such as the lack of information on technology and market, and the lack of qualified personnel, have a negative effect on the development of eco-innovations. Finally, Hypothesis 1c is supported, since the variable *Market Uncertainty* has a significant and negative impact ($ß = -0.463$, $p < 0.01$) on the development of eco-innovation, which indicates that the lack of market information and the uncertainty of the market have a negative effect on the development of eco-innovation in the firm. In general, regarding the hindering factors in the eco-innovation management, the results corroborate the literature showing that the cost and finance of eco-innovation are a disincentive for its development (Cuerva et al., 2014). These results are reinforced by the "double externality" hypothesis, which states that the costs of eco-innovation are a disincentive for the firm due to the social nature of environmental developments, which will subsequently allow other firms to access these eco-innovations without incurring the costs and risks (Amores-Salvado et al., 2015). Moreover, the results show the importance of market uncertainty for eco-innovation and that the potential viability of a product negatively affects the development of eco-innovation. This corroborates previous studies that noted that uncertainties in consumer perception and market saturation are an obstacle for eco-innovation (Cuerva et al., 2014). Furthermore, our results corroborate that management ambidexterity and the establishment of cooperation agreements for eco-innovative development are additional difficulties in this process.

Table 5b shows the effect of the external facilitating factors in the eco-innovation of the firm. In Model 10, we observe that the variable *Cooperation for Innovation* ($ß = 0.123$, $p < 0.05$) and *Information Sources* ($ß = 0.246$, $p < 0.01$) have a positive effect on the eco-innovations. These results support the hypotheses 2a and 2b, pointing out that the establishment of cooperation agreements and the use of information sources for innovative development have a positive effect on the development of eco-innovation in the firm. Furthermore, the *Public Funding* variable has also a positive effect on the development of eco-innovation (Model 10), both locally ($ß = 0.223$, $p < 0.05$) and nationally ($ß = 0.329$, $p < 0.01$). However, EU funding is not significant in developing eco-innovations, in spite of the fact that these policies have been mainly aimed at financing projects for new environmental

technologies (especially in SMEs), as well as encouraging the creation of European business and technology centres (Mazzani and Zoboli, 2006). Therefore, our results show that the regional or national levels have a positive effect on the eco-innovations in companies. Therefore, concerning external facilitating factors in the eco-innovations, our results confirm previous studies that highlight the necessity to obtain scientific information from universities and research centres, international standards from environmental agencies, and information regarding the readiness of production inputs from suppliers in the developing of eco-innovations (Kemp et al., 2006). Moreover, the results highlight the key role of cooperation in the environmental innovation objectives. Previous literature has shown vertical and horizontal cooperation is very important, reducing the environmental impact and ensuring the eco-friendly features of inputs. Availability of information and reciprocal learning (from cooperation) between clients and suppliers have shown to be key in reaching environmental goals, in combination with the collaboration with universities and research institutions, in light of the complexity of developing eco-innovations (Cuerva et al., 2014; Cai and Zhou, 2014). Additionally, in line with Horbach (2008), and Manzini and Zoboli (2006) our results show that financial incentives facilitate the eco-innovation development, especially at a local, regional and national geographical level.

Finally, in relation to the control variables, our results show a positive impact on the size of firms on eco-innovation. Although our results show that small and medium companies have assumed at least one environmental objective, our analysis reinforces the hypothesis about the size, showing that this is a key element in the development of eco-innovation in the company. This has been a classic result in the innovation and environmental literature, showing that large companies have a greater predisposition for the adoption of environmental objectives. In fact, the SMEs, with limited financial resources, cannot implement lengthy processes in the development of competencies, as well as supporting important ecological activities (De Medieros et al., 2018; Marin et al., 2015). Moreover, the results show that the manufacturing sector is more sensitive to the eco-innovation objectives than the service sector. This confirms that the manufacturing sector has a greater incidence of environmental problems, such as the long-established issue of the elimination of toxic waste (both gaseous and liquid), as well as the challenge of energy saving. Finally, the results illustrate that the support of the company group has a positive impact on certain types of innovation objectives. It is well established in the literature that the corporate environmental strategy determines the adoption of environmental quality standards, management, and clean production processes. This evidence shows that the group determines environmental policies, which is a component

of the corporate social responsibility policy of the firms (Choi et al., 2016; Horbach et al., 2012).

4. Conclusions

The goal of our work is to investigate the incentives and inhibiting factors of eco-innovation in the firm, using a sample of Spanish firms. Unlike other studies that have been focused on the effect of policies and regulations (Choi et al., 2016, Constantini et al., 2017), are framed in the field of industrial organization ((Triguero et al., 2013; Bossle et al. al., 2016), or take a decision-making perspective (Marousek et al., 2015), our paper differs by considering that the innovation capacity of the firm is a key factor in the development of eco-innovation. Our results show that the innovation capacities of the firm encourage environmental innovations. Thus, companies develop eco-innovation in a dynamic process of interaction of skills, abilities, routines and resources for innovation. Moreover, the results highlight that this process is conditioned by factors that hinder or facilitate the eco-innovation capacity of the firms. More in detail, the first group of hypotheses highlight that the perception of the high costs and the necessary financing that development of eco-innovation suppose hindering factors in the development of the eco-innovation. The lack of knowledge, the qualified personnel and the information is the second group of obstacles in the development of eco-innovations. Finally, the uncertainty of the demand for eco-innovative goods and services and the saturation of the market, appear as obstacles for the development of eco-innovation in the firm. On the other hand, we have proposed a group of hypotheses that suggest that the efforts of the National Innovation Systems can compensate for these obstacles, incentivising the development of eco-innovations. Our results corroborate these hypotheses pointing out that an adequate framework that provides information to companies both for the search of partners and market possibilities, as well as the existence of financial incentives facilitate eco-innovation in the firm.

From our results, we can propose some management actions for the firms and policymakers. Firstly, we have seen that an obstacle for companies is the lack of market information. It would be necessary to develop push and pull policies that involve companies. On the one hand, companies must take advantage of the fact that consumer positively value intangible aspects of products and services, developing a new market for the eco-innovation. The European Union (2015) points out that this market is fast-growing far above the average (from 17% in 1975 to 84% in 2015). On the other hand, companies should assume eco-innovation as a strategic objective, seeking not only to reduce costs or gain efficiency, but

also to gain competitive advantages through the positioning of products, services, and brands (Sala et al., 2017). In this sense, Boston Consulting Group (2009) showed that consumers perceive the products with better environmental performance with higher quality, and consequently, their willingness to pay more is higher (Manget et al., 2009). Second, our results highlight the deficiencies of external financing as a difficult for firms to develop eco-innovation activities. In this sense, specific programs should be developed for firms, encouraging and financing the eco-innovations. In addition, the permeability of environmental actions and development should be increased in the rest of the R&D and innovation policies. Third, the lack of knowledge of the company to develop environmental innovation requires a series of measures. Companies should investigate new eco-innovative developments. In this sense, vertical cooperation is very important both with customers and with suppliers for the creation of new products and services. The cooperation with clients might provide complementary skills or knowledge, mitigating the risks and difficulty associated with the implementation of the eco-innovation (Hagedoorn et al., 2000). In addition, cooperation with suppliers is necessary for the eco-innovation. In this sense, eco-innovation translates into an increase in environmental requirements over suppliers, exerting traction on the entire supply chain. The companies that are leading this process transfer their environmental requirements through the implementation of environmental systems (ISO 14001) in the supply chain. Lastly, these findings indicate two suggestions that can be made to policy-makers. Thus, it is necessary to increase the permeability of eco-innovation in R&D and innovation programs. The proximity of the two types of innovation should facilitate eco-innovative development. Our results show that there exists parallelism between the knowledge and competencies necessary for the development of eco-innovation and those needed for conventional innovation, highlighting the interrelationship of both processes, so that firms that have already developed innovations are more susceptible to develop eco-innovations.

Finally, like any research, our paper is subject to the limitations of the sample choice. The more important limitation is the geographical scope; our empirical study is limited to Spain. Obviously, the question is open about the generalisation of the results. Research must aim to study the eco-innovation developing in countries, with more institutional and financial support to develop eco-innovation in the firm.

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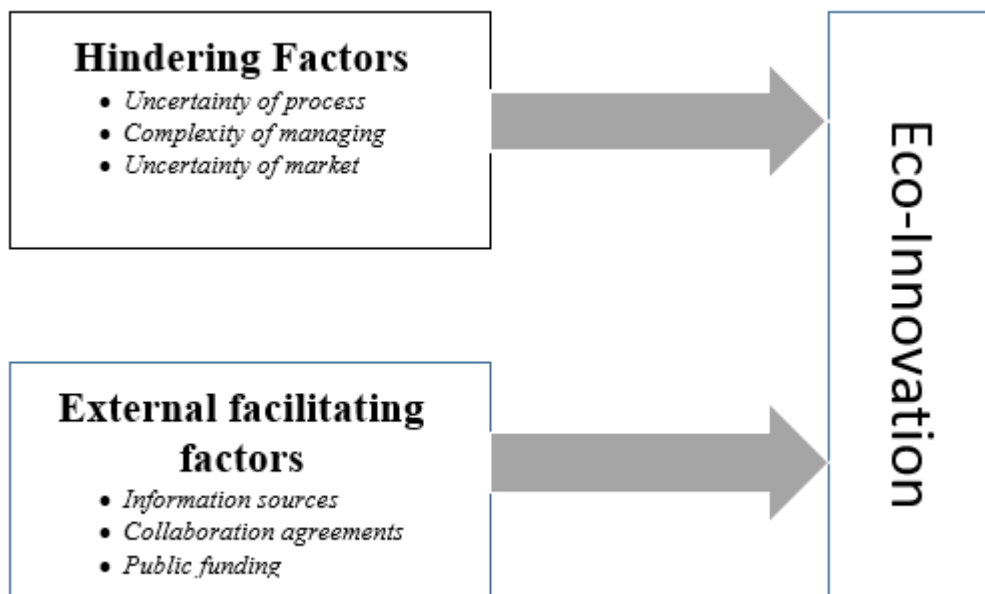
Table 1a

Conceptualisation of eco-innovation

Eco-innovation	• Eco-innovation aims to develop new processes, products and techniques to avoid environmental damage (Kemp et al., 2006). • Eco-innovation also includes new knowledge and organizational innovation (OECD, 2009). • Eco-innovation is the innovation for sustainability (Vellinga and Herb, 1999); Walz and Kuhlmann, 2005)
Key elements of eco-innovation [5]	• Eco-innovation has to do with innovations that generate environmental improvements. • Eco-innovation must obtain an additional value for the producer and the consumer. • Eco-innovation must reach the market either by opening new business niches or by generating better competitive behaviour. • Eco-innovation must imply a net environmental improvement.
Eco-innovation and Innovation	
Similarities	• Eco-innovation as an innovation that is able of producing environmental and sustainable products and services. (Kemp et al., 2006)
Differences	• Eco-innovation generates a *'win-win'* setup characterized by compatibility of economic development and a sustainable economy (Arena et al., 2017). • Eco-innovation is aimed at fostering sustainable development (Walz and Kuhlmann, 2005; Wellinga and Herb, 1999). • Eco-innovations are originated from environmental problems that need urgent solutions (Choi et al., 2016). • Eco-innovation has as characteristic the *double externality*. *Double externality* refers to the absence of incentives for firms to invest in eco-innovation. The reduction of environmental damage by innovators reduces the pressure on other polluting firms, since there is a social benefit, without the latter having to adopt any measures (Porter and Van der Linde, 1995). • Eco-innovation has as characteristic the *regulatory push/pull effect*. While new technology solves environmental problems in the firms, environmental regulation and policy are responsible, also, for these environmental improvements. (Constantini et al., 2017; Choi et al., 2016).

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[5] Eco-innovation is often used interchangeably with environmental innovation. However, environmental innovation is linked with environmental technology or eco-efficiency, which pursues the development of more sustainable production and consumption models, with less environmental impact and with an efficient and responsible use of the natural resources (Jové-Llopis and Segarra-Blasco, 2018; Liao, 2018b; Liao et al., 2018; Kiefer et al., 2017).

Figure 1
Conceptual Model

Table 1b
Hypotheses

Hindering Factors: the complexity of the eco-innovation process
Hypothesis 1a: The obstacles derived from the management of costs and financing of the eco-innovation process have a negative effect on firms' eco-innovation.
Hypothesis 1b: The difficulties in managing the eco-innovation process have a negative effect on firms' eco-innovations.
Hypothesis 1c: The uncertainty of the market has a negative effect on firms' eco-innovations.
External facilitating factors in the eco-innovation objectives
Hypothesis 2a: The available information has a positive effect on firms' eco-innovations.
Hypothesis 2b: The cooperation agreements have a positive effect on firms' eco-innovations.
Hypothesis 2c: Financial facilities have a positive effect on firms' eco-innovations.

Table 2
Variables and Measures

Measure	Variables	Scale
Eco-innovation	• Less energy per production; • Lower environmental impact; • Improvement in health and safety; • Compliance with regulatory, environmental, health, or safety requirements	1, 0
Hindering factors in the eco-innovation process		
Costs and	• Lack of funds in the firm or group of firms;	1,2,3,4

Finance	• Lack of funding from sources outside the company; • Innovation's high cost	
Innovation Process	• Lack of information on technology; • Lack of information about the markets; • Lack of qualified personnel; • Difficulties in finding cooperation partners for innovation	1,2,3,4
Market Uncertainty	• Uncertainty regarding the demand for eco-innovative goods and services; • Market dominated by established firms	1,2,3,4
External facilitating factors in the eco-innovation objectives		
Information Sources	• Suppliers; • Customers; • Competitors; • Consultants and commercial laboratories; • Universities; • Public research bodies; • Technology centres; • Conferences, trade fairs and exhibitions; • Scientific journals; • Professional and industry associations	1, 0
Cooperation for Innovation	• Cooperation	1, 0
Public Funding	• From local or regional governments; • From the national government; • From the European Union.	1, 0
Variables of control		
Size	• Logarithm of the number of staff in the firm	Continuous
Sector	• Manufacturing/Services	1,0
Group	• Group	1,0
International	• Local; • National; • EU; • Other countries (China and India)	1,0

Table 3

Exploratory Analysis

Variables	Eco-innovation				
	0		**1**		**Total**
	N	**%**	**N**	**%**	**N**
Environmental	1999	36.7	3462	63.3	5461
Manufacturing	893	29.9	2117	70.1	3010
Services	937	38.3	1514	61.7	2451
Internationalization	1366	23.3	3700	67.7	5461
Cooperation	0	0	2353	100	2353
Size:					
10-49	973	38.9	1528	61.1	2501
50-249	565	30.0	1318	70.0	1883
>250	398	36.9	679	63.1	1077
Group	1274	32.4	2657	67.6	3931
R&D Department	0	0	3663	100	3663
Information Sources	0	0	5461	100	5461
Public Funding	16	7.8	2022	92.2	2038

Table 4a
Correlation Analysis

		1	2	3	4	5	6	7
1.	Costs and Finance	1						
2.	Innovation Process	.000	1					
3.	Market Uncertainty	.000	.000	1				
4.	Firm Size	-.034**	-.002	-.022*	1			
5.	Manufacturing/Services	-.036**	-.056**	-.064**	.101**	1		
6.	Group	-.116**	-.016	.014	.141**	.003	1	
7.	International	.008	.035**	.112**	-.032**	-.379**	.139**	1

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 4b

Regression Analysis between hindering factors and eco-innovations

	Model 1		Model 2		Model 3		Model 4		Model 5	
	Less Energy		**Lower Impact**		**Improvement Health and Safety**		**Regulatory Requirements**		**Environmental Objectives**	
	Estimated	**Error**	**Estimated**	**Error**	**Estimated**	**Error**	**Estimated**	**Error**	**Estimated**	**Error**
Costs and Finance	-.560***	.025	-.552***	.025	-.529***	.025	-.540***	.025	-.554***	.024
Innovation Process	-.441***	.023	-.418***	.023	-.434***	.023	-.427***	.023	-.449***	.023
Market Uncertainty	-.434***	.021	-.440***	.022	-.447***	.022	-.472***	.022	-.463***	.021
Firm Size	6.016E-005***	1.317E-005	6.947E-005***	1.378E-005	6.706E-005***	1.364E-005	5.459E-005***	1.346E-005	6.369E-005***	1.281E-005
Manufacturing/Services	-.338***	.043	-.292***	.043	-.316***	.043	-.293***	.043	-.353***	.043
Group	.606***	.041	.569***	.041	.547***	.041	.530***	.041	.585***	.041
International	.517***	.024	.525***	.024	.525***	.024	.527***	.024	.520***	.024
-2 Log Likelihood	25005.845		25014.919		24916.472		24928.322		36569.727	
Chi-Square	1980.649		1992.468		1992.222		1955.286		2089.918	
df	7		7		7		7		7	
Sig.	.000		.000		.000		.000		.000	
Cox and Snell	.194		.195		.195		.192		.204	
Nagelkerke	.205		.206		.206		.203		.207	
McFadden	.073		.073		.074		.072		.054	

*p<0.10, **p<0.05, *** p<0.01

Table 5a
Correlation analysis

	1	2	3	4	5	6	7	8	9
1. Information Sources	1								
2. Cooperation	.382**	1							
3. Local or Regional	.357**	.225**	1						
4. National	.444**	.315**	.311**	1					
5. European Union	.274**	.251**	.292**	.329**	1				
6. Firm Size	.057**	.071**	.008	.019	.036**	1			
7. Manufacturing/Services	-.130**	.030*	-.011	-.033**	.066**	.101**	1		
8. Group	.157**	.183**	.034**	.102**	.019	.141**	.003	1	
9. International	.325**	.067**	.117**	.200**	.087**	-.032**	-.379**	.139**	1

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 5b

Regression Analysis between facilitating factors and eco-innovations

Variables	Model 6 Less Energy		Model 7 Lower Impact		Model 8 Improvement Health and Safety		Model 9 Regulatory Requirements		Model 10 Environmental Objectives	
	Estimated	**Error**	**Estimated**	**Error**	**Estimated**	**Error**	**Estimated**	**Error**	**Estimated**	**Error**
Information Sources	.234***	.004	.243***	.004	.247***	.004	.248***	.004	.246***	.004
Cooperation for Innovation	.097*	.056	.143*	.058	.107*	.058	.091**	.054	.123**	.052
Public Funding:										
• Local or Regional	.141*	.071	.254**	.073	.242**	.073	.234**	.074	.223**	.067
• National	.302**	.067	.304***	.068	.352***	.068	.390**	.069	.329***	.063
• European Union	.129	.105	.129	.108	.003	.107	-.017	.109	-.020	.098
Firm Size	3.773E-005**	1.423E-005	5.446E-005***	1.494E-005	5.158E-005**	1.491E-005	2.768E-005*	1.485E-005	4.329E-005**	1.323E-005
Manufacturing/Services	-.758***	.054	-.752***	.055	-.751***	.055	-.732***	.055	-.853***	.052
Group	.215***	.052	.160**	.053	.120*	.053	.081	.053	.126**	.050
International	.003	.031	-.008	.031	.008	.031	.011	.031	-.013	.029
-2 Log Likelihood	15553.828		15178.983		15001.842		15008.376		26196.655	
Chi-Square	11534.478		11932.412		12013.633		11978.430		12557.869	
df	9		9		9		9		9	
Sig.	.000		.000		.000		.000		.000	
Cox and Snell	.716		.728		.730		.729		.746	
Nagelkerke	.755		.768		.771		.770		.757	
McFadden	.425		.440		.444		.443		.324	

*p<0.10, **p<0.05, *** p<0.01