Title: **Driving sectoral sustainability via the diffusion of organizational eco-innovations**

Running title: **Driving sectoral sustainability**

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## ABSTRACT

Using insights from institutional literature, the resource-based theory of the firm, and internationalization, we explain variations in the diffusion of organizational eco-innovations. Studies have previously reported that the drivers of eco-innovation are regulatory pressures, technology push, market pull, and firm factors. But relatively little attention has been paid to nontechnological forms of eco-innovation, such as environmental management systems (EMS). Consequently, how exactly to encourage EMS adoption across sectors is still unclear. We attempt to address this question by combining sectoral panel data (2009–2014) from a number of sources in Spain. The econometric analysis reveals that environmental policy is driving the adoption of ISO 14001 largely due to differences across sectors in energy and pollution intensity. In addition, the adoption of ISO 9001 increases the use of ISO 14001 in industry because of complementarities between the two systems. Third, in highly internationalized sectors, firms adopt a greater amount of ISO 14001.

**KEYWORDS:** organizational eco-innovation, EMS, ISO 14001, environmental policy, complementarities, internationalization

**JEL Classification:** Q50, Q55, Q58

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## 1. INTRODUCTION

How organizations manage their environmental performance has become a strategic issue for many companies, and this reflects the extent to which the environment is now viewed as a valuable asset. Managers today are expected not only to reduce lead times, improve quality, reduce costs, and enhance flexibility, but also to be more environmentally responsible (Montabon, Melnyk, Sroufe, & Calantone, 2000). During the past ten years an increase in research on eco-innovation has shed light on ways in which companies could progress along the path towards environmental sustainability (e.g. Horbach, Rammer, & Rennings, 2012; Kesidou & Demirel, 2012; Marzucchi & Montresor, 2017; Zubeltzu-Jaka, Erauskin-Tolosa, & Heras-Saizarbitoria, 2018). Yet less attention has been given to different types of eco-innovation (Triguero, Moreno-Mondéjar, & Davia, 2013). For instance, eco-innovations might take the form of eco-products or eco-processes (Triguero et al., 2013). There could be technological eco-innovations or nontechnological types of eco-innovation (Demirel & Kesidou, 2019).

This paper focuses on nontechnological eco-innovations. Organizational eco-innovations are vehicles of corporate environmental self-regulation that facilitate the introduction of significantly different organizational structures, corporate environmental strategies, and new management methods (OECD, 2009; Ziegler & Nogareda, 2009). Well-known examples of organizational eco-innovations include environmental management systems (EMSs), which, since the 1990s, have become standard environmental protection policy tools due to their greater flexibility and costs that are lower than those of traditional regulatory tools (Demirel, Iatridis, & Kesidou, 2018; Frondel, Horbach, & Rennings, 2008).

Previously EMSs were usually seen as drivers of environmental investment and effort. Over the past twenty years, environmental management has moved from being simply a matter of "command and control" to increased awareness of the need for self-regulation and an acceptance of public accountability and consultation (Iatridis & Kesidou, 2018). Some companies are actually now using environmental issues to strengthen their market position and access new markets. In recent decades, voluntary proactive approaches to environmental protection have been accepted as proper additions to traditional mandatory command-and-control regulation and economic incentives (Khanna & Damon, 1999). Instances of the voluntary engagement of firms, with the objective of improving their environmental impact, have been increasing, creating competitive advantages and improving stakeholder relationships (Bansal & Roth, 2000; González-Benito & González-Benito, 2005; Prajogoyog, Tang, & Lai, 2012; Singh, Jain, & Sharma, 2015). However, some criticism has been directed at these practices on the grounds that proactive actions of this kind merely represent symbolic decisions (Aravind & Christmann, 2011; Gavronski, Ferrer, & Paiva, 2008).

The purpose of this research is to analyse the reasons underlying differences in sustainability among sectors by taking note of their respective levels of certified forms of organizational eco-innovation (i.e. ISO 14001). Enhancing sustainability may require a systemic approach at the sectoral level. For instance, corporate social responsibility (CSR) tools, which are adopted by many companies, have been criticized as not comprehensive enough to bring about transformative change. Instead, sectoral approaches, such as the Sustainable Apparel Coalition or the Sustainability Accounting Standards Board, are increasingly seen as the key to driving sustainability (Hohnen, 2013), which they do by applying organizational eco-innovations across a whole sector and along the supply chain. Using insights from institutional theory, resource-based theory, and the internationalization literature, we attempt to explain variations in adopting organizational eco-innovations. First, we contend that coercive institutional pressures, such as government mandates (DiMaggio & Powell, 1983; Oliver, 1997), are driving the adoption of EMSs. Considering that sectors differ in the intensity of their energy use and levels of pollution, the pressures to comply with regulations across sectors also differ (Agnolucci & Arvanitopoulos, 2019; Cole, Elliott, & Shimamoto, 2005). Second, we argue that EMSs are more readily adopted in sectors that have already implemented quality management systems such as ISO 9001. This can be explained in terms of the benefits that arise from resource complementarities (Teece, 1986), so that the adoption of ISO 9001, for example, allows organizations to develop intangible processes and routines that facilitate the adoption of eco-innovations such as EMS (Darnall & Edwards, 2006). Third, this paper postulates that organizational eco-innovation is driven by differences across sectors concerning their need to signal to international markets that they do actually abide by the required safety and environmental standards (Christmann & Taylor, 2006; Yeung & Mok, 2005).

We gather together data from the following Spanish sources for the period 2009–2014: the International Organization for Standardization (ISO) survey, the Statistics on R&D

activities, the Technological Innovation Panel, the Industrial Companies Survey, the Environmental Protection Survey, and the Environmental Tax Account. By using data from these multiple sources we can include information on a broad range of factors that may be driving the adoption of EMS across all industrial sectors. We also gain the advantages of using panel data for our econometric estimations.

The paper is organized as follows. First, we review the literature on the drivers of organizational eco-innovation across sectors and develop the conceptual framework of this research. Next, we present the empirical framework and the panel dataset. Finally, we discuss the results of the analysis and underline the main contributions made by our study.

## 2. THEORY AND HYPOTHESES

### 2.1. Organizational eco-innovations: Certified environmental management systems

An EMS is a set of processes and practices that make it possible for an organization to reduce its environmental impact and increase the efficiency of its operations. It is a form of organizational eco-innovation as it allows an organization to achieve its environmental goals through the consistent monitoring, evaluation, and improvement of its environmental footprint. An EMS itself does not prescribe a level of environmental performance that has to be achieved; rather, each organization's EMS is tailored to its own individual objectives and targets. Because of this, an EMS helps an organization meet regulatory demands in a systematic and effective way. This kind of proactive approach can be useful in reducing the risk of noncompliance and improve health and safety practices for employees and external stakeholders alike.

Many firms have now chosen to introduce some form of organizational eco-innovation to address their environmental concerns, and some firms also choose to be certified according to recognized international standards. This paper focuses on ISO 14001 as a certified form of organization eco-innovation.[1] As Testa, Rizzi, Daddi, Gusmerotti, Frey, and Iraldo (2014) describe in some detail, there are two main international standards that set the requirements for an EMS: ISO 14001, designed by the ISO, and the Eco-

[1] Certified EMSs, such as ISO 14001, are a subset of organizational eco-innovations. Firms may adopt an EMS without seeking certification.

Management and Audit Scheme (EMAS), regulated by the European Regulation EC 1221/2009. Both standards have become aligned over time, as they seek to pursue similar objectives, but there are still a number of notable differences.

First, they differ in nature. EMAS registration is issued by a public body while ISO 14001 is a private norm. Second, ISO 14001 has been valid internationally since its introduction, while EMAS was initially endorsed exclusively in Europe and only gained international validity in 2010. Third, EMAS is stricter regarding external communication, requiring a mandatory document detailing key indicators on environmental performance. In this sense, EMAS is considered a better tool for communicating the environmental commitments of companies to their external stakeholders. Finally, ISO 14001 is open to all sectors, while EMAS is experimentally adopted by industrial organizations and at the territorial level.

In general, firms are under no legal obligation to obtain ISO 14001 – or any type of environmental certification, for that matter – from either the ISO or another EMS-certifying organization. It may be for this reason that many studies to date have examined the effectiveness of adopting an EMS for a firm's environmental performance (e.g., Montabon et al., 2000; Montobbio & Solito, 2017; Testa et al., 2014), and an increasing number of studies ask why firms participate in voluntary environmental programmes (Arora & Cason, 1995; Blackman, 2007; Quazi, Yee-Koon, Chin-Meng, & Poh-Seng, 2001), and why firms opt to certify their EMSs under various voluntary certification schemes (Klassen & McLaughlin, 1996; Peiró-Signes, Segarra-Oña, Verma, Mondéjar-Jiménez, & Vargas-Vargas, 2014).

In sum, this paper contends that sectors can become more sustainable via the diffusion of certified forms of organizational eco-innovation. By contrast, prior literature on eco-innovation has paid more attention to technological forms of eco-innovation (Horbach, Rammer, Rennings, 2012, Kesidou & Demirel, 2012: Marzucchi & Montresor, 2017). However, the drivers as well as the impact of technological versus organizational eco-innovations may be different (Triguero et al., 2013).

### 2.2. Institutional perspectives of eco-certification: Environmental policy

Institutional theory holds that organizations often behave in a similar way (i.e., are isomorphic) when functioning within similar social structures (Scott, 2001). Organizations abide by prevailing institutionalized norms, values, and assumptions (Meyer & Rowan, 1977) because of the risk that if they do not, they will lose legitimacy (DiMaggio & Powell, 1983). This theory claims that institutional compliance may be as important as, or even more important than, motives of profit maximization (Scott, 2001), since a lack of legitimacy may threaten an organization's survival (Suchman, 1995). Research on institutional theory contends that institutional compliance may not only reduce potential threats to the organization (e.g., sanctions, fines, and boycotts) but may even improve organizational performance (Deegan & Rankin, 1996; Oliver, 1997).

It is necessary for organizations to respond to a range of institutional pressures, be they coercive, mimetic or normative (DiMaggio & Powell, 1983; Oliver, 1997). Coercive isomorphism includes government mandates or contractual obligations with which an organization is forced to comply; mimetic isomorphism occurs when organizations imitate the structures or practices of successful organizations in their sector; and normative isomorphism is driven by the prevalence of professional standards within a sector.

Previous studies of EMSs, and particularly eco-certification, use institutional theory to explain how EMSs and certified forms of EMS are used by firms to fulfil their responsibilities to their stakeholders, thus sustaining and enhancing their legitimacy (Delmas, 2002; Demirel et al., 2018; González-Benito & González-Benito, 2005; Jiang & Bansal, 2003; Khanna & Anton, 2002). However, the fact that coercive, mimetic, and normative pressures might affect firms in different sectors in different ways has received less attention.

The focus of this paper is on coercive pressures. Coercive isomorphism might be apparent at the sectoral level, as sectors differ with respect to their energy and pollution intensity, and consequently pollution regulations and taxes could be more or less stringent in specific sectors (Agnolucci & Arvanitopoulos, 2019; Cole et al., 2005). This would, in turn, affect compliance with, and adoption of, eco-certification. This allows us to formulate our first hypothesis:

*H1: Firms operating in sectors with stricter regulatory pressures exhibit a greater likelihood of eco-certification.*

## 2.3. Resource complementarity perspectives on eco-certification

Previous research on variations across countries in the adoption of eco-certification shows that the implementation of ISO 9001 facilitates the diffusion of ISO 14001 (Corbett & Kirsch, 2001; Vastag, 2004). Research at the firm level also indicates that firms with quality-based management systems are more likely to adopt EMSs because the costs are lower (Darnall & Edwards, 2006).

The joint adoption of ISO 9001 and ISO 14001 can be explained theoretically by drawing on insights from the resource-based theory of the firm (Barney, 1991) and the literature on asset complementarity (Ozusaglam, Kesidou, & Wong, 2018; Teece, 1986). When firms implement quality management systems (e.g. ISO 9001), they develop intangible and knowledge-based processes that can make the adoption of eco-certification easier (Demirel & Kesidou, 2019; Darnall & Edwards, 2006). This is so because firms that adopt ISO 9001 have already built tacit capabilities and routines across their organizations and have embraced a systematic process of organizational change based on monitoring, assessment, and action that is very similar to that needed for ISO 14001. For instance, Zhu, Cordeiro, and Sarkis (2013) emphasize the path-dependent character of organizational learning and show that Chinese firms that have prior experience with ISO 90001 are more prone to also adopting ISO 14001.

To sum up, based on the above insights, it would be expected that sectors characterized by high levels of adoption of ISO 9001 – a highly institutionalized quality management system – also present high rates of adoption of ISO 14001.

*H2: Sectors with high rates of ISO 9001 adoption exhibit a greater likelihood of eco-certification.*

## 2.4. Eco-certification and internationalization

Eco-certification may also be motivated by a need to signal to international capital and export markets that a firm does in fact abide by required safety and environmental standards (Christmann & Taylor, 2006; Yeung & Mok, 2005). Pressures from powerful global suppliers or multinational corporations may push firms to adopt eco-certifications, especially if they want to be integrated into global supply chain networks (King, Lenox,

& Terlaak, 2005; Withers and Ebrahimpour, 2000). Both these factors imply that sectors that are export intensive may be more likely to meet to eco-certification requirements so as to access foreign markets (Bodas Freitas & Iizuka, 2012).

Internationalization might affect eco-innovations via different mechanisms. For instance, a recent study by Chiarvesio, De Marchi, and Di Maria (2015) explores, in the context of Italy, three channels via which internationalization could drive eco-innovation, namely, outsourcing, exporting, and being part of a multinational corporation. The role of multinational corporations in reinforcing eco-innovation is also stressed in Cainelli, Mazzanti, and Montresor's (2012) study. In this paper we focus on one channel of internationalization, i.e. exporting.

*H3: Highly internationalized sectors exhibit higher rates of eco-certification.*

[Insert Figure 1 around here]

Figure 1 summarizes the conceptual framework of this research, which integrates insights from institutional theory, a resource-based view of the firm, and internationalization theory. Prior research has examined the impact of environmental regulations upon self-regulations (cf. Demirel et al., 2018). Yet none of the past research, to our knowledge, takes into account in a holistic framework internal complementarities arising from ISO 9001, or external regulatory and market internationalization pressures. For instance, González-Benito and González-Benito (2005) examine the ethical, competitive, and relational drivers of ISO 14001, yet they do not consider internal complementarities and fail to account adequately for the effects of internationalization. Our theoretical framework takes into account these factors and demonstrates their importance for the diffusion of eco-certification across sectors. The contribution of this paper lies in the conceptual framework, which widens the theoretical boundaries of eco-innovation research by (a) focusing on a specific type of eco-innovation, namely, the certified form of organizational eco-innovation, (b) considering complementarities arising from the adoption of similar organizational certifications – ISO 9001-quality standard – as a likely factor that facilitates the diffusion of organizational eco-innovations, and (c) extending the drivers of organizational eco-innovations to include insights from internationalization theory.

## 3. EMPIRICAL FRAMEWORK

Previous empirical studies describing the determinants of the adoption of environmental certification often mention the characteristics of environmental practices or the impacts of these practices on a firm's strategy and performance. Quazi et al. (2001), for example, propose a model, tested on a small sample of firms in a number of specific industries, that can predict the intentions or motives of a company in seeking ISO 14001 certification. Recent empirical research examining the drivers of environmental certification has increasingly attempted to include the factors that, according to different theoretical approaches – most notably institutional theory and the resource-based view of the firm – explain the motivations and drivers that encourage firms to adopt these environmental practices (Cole, Elliot, & Shimamoto, 2006; Neugebauer, 2012; Nishitani, 2009; Singh et al., 2015). However, the empirical approach is usually based on cross-sectional survey data for certain industries (González-Benito and González-Benito, 2005). This study differs in that we use panel data for 16 manufacturing sectors for the period 2009–2014. Sectors differ in their energy use and pollution intensity (Agnolucci & Arvanitopoulos, 2019; Cole et al., 2005), and therefore, we argue in this paper, their approaches to sustainability may be different.

### 3.1. Data and variables

Data availability is a common constraint of empirical analyses in environmental economics. For this reason, information must be collected from various databases in order to examine the drivers of environmental certification. In this paper we depart from the database constructed by Costa-Campi, García-Quevedo, and Martínez-Ros (2017) to build a comprehensive dataset from a range of different sources and surveys for 16 manufacturing sectors for the period 2009–2014. The set of variables used is summarized in Table 1.

[Insert Table 1 around here]

**Dependent variable**

The main agency for environmental certification is the ISO. To measure environmental certification, we use ownership of approved ISO 14001 certification, which, as Kesidou and Demirel (2012) and Testa et al. (2014) confirm, is one of the most usual forms of EMS. Information about ISO 14001 accreditation in the Spanish manufacturing sector is provided directly by the ISO, but has only been available since 2009. This information is now published every year on the ISO website. All firms that wish to set up an EMS can use the ISO 14001 to certify their processes. The ISO website also contains information about other certificates, including ISO 9001 (quality management) and ISO 5001 (energy management systems). In addition, and as a robustness test, we also use information from EMAS. The European Commission maintains the original source of this data.

**Independent variables**

The Spanish Institute of Statistics (INE) carries out various surveys that provide the information used for the independent variables. They include the following: the Industrial Companies Survey, an annual report covering the main features of both firms and sectors (e.g., the number of firms in each sector, the number of employees, and sales and export figures); the Survey on Industry Expenditure on Environmental Protection, which reports on spending by firms on environmental protection in a given industry, distinguishing between current expenditure and investment (divided between "end-of-pipe" solutions and integrated equipment); the Environmental Tax Account, from which information is taken about the pollution taxes paid by each industrial sector; and the Statistics on R&D Activities, which provide information about environmental research and development. All these surveys are anonymous and mandatory for the firms involved. They all use the same classification of economic activities. INE publishes annually the information at industry-level and guarantees its representativeness. In addition to these surveys, we have used the Technological Innovation Panel, also compiled by the INE, which provides information of sales at firm level, to calculate the Herfindahl-Hirschman index (HHI) of concentration for the industries of our analysis. In Table 2, we present the descriptive statistics.[2]

[Insert Table 2 around here]

[2] The correlation matrix is reported in Table 1 in the Appendix.

### 3.2. An initial appraisal of Spain's EMSs by sector

Table 3, which shows the percentage of firms with an EMS, underlines the fact that the number of firms with an ISO 14001 is much higher than those with EMAS registration. Second, and more importantly with regard to the objectives of this analysis, there are considerable differences between different industries in their use of EMS, and especially in the case of ISO 14001.

[Insert Table 3 around here]

Coke and refined petroleum products, chemicals, pharmaceutical products, and motor vehicles are the four sectors in which the implementation of ISO 14001 is most common. ISO 14001 has been adopted by more than 15% of firms in these four sectors, the highest proportion being in the coke and refined petroleum industry. This sector contains very few firms, all of which have adopted ISO 14001.

The main reasons for the greater adoption of this certificate in these sectors are related to the characteristics of each sector. First, these industries display a high level of environmental commitment. Many firms participate in multilateral agreements, particularly in the chemical industry. Second, the environmental impacts of all four sectors are governed by common and extremely stringent regulations.

Third, these industries are highly internationalized, with regard not only to sales to foreign markets, but also to the share of foreign capital in their ownership. Quality management systems are also prevalent in these industries: that is, in 100.0% of firms in the coke and petroleum sector and 60.7% of firms in the pharmaceutical sector. At the same time 38.0% and 36.8% of firms respectively in the chemicals and motor vehicles sectors have adopted ISO 9001. These rates are well above the average reported for manufacturing industries. Already having quality management systems in place makes the adoption of an EMS easier, primarily because of the knowledge acquired, but also because these management systems require a higher degree of integration.

Close behind these four sectors, the computers, electronics, optical products, and electrical equipment sector (14.5%) and the machinery and equipment sector (11.7%) are two more sectors in which there is a considerable degree of adoption of ISO 14001. These two industries share many of the characteristics of the other four industries, especially as regards their degree of internationalization and the earlier adoption of quality management systems.

Finally, there are sectors with a very low degree of adoption of ISO 14001. These are textiles and wearing apparel; leather products; furniture and other manufacturing activities; and wood, and wood and cork products. In these sectors, fewer firms have adopted an EMS. These industries are also the four sectors that present the lowest degree of adoption of ISO 9001. They are characterized by a particularly high number of small low-technology-content firms.

### 3.3. The empirical specification

We test the three hypotheses empirically via the following model specification:

$$EC_{it} = \beta_0 + \beta_1 Institutional_{it} + \beta_2 Complementary_{it} + \beta_3 Internationalization_{it} + \beta_4 Z_{it} + \mu_i + e_{it} \quad (1)$$

*Institutional* refers to the external pressures on industry, including such factors as pollution taxes, compliance with environmental norms, and the fulfilment of corresponding legal requirements in order to operate in a given market. A considerable number of papers have stressed the importance of taking into account measures concerning policy regulation and support for encouraging eco-innovation (Del Río, 2009; Horbach et al., 2012; Marin, 2014). The empirical literature on the adoption of ISO 14001 has also shown that government policy is an important factor. Therefore we include taxes with environmental objectives, pollution, and resources as a potential factor that may explain environmental certification.

*Complementary* refers to a sector's experience in obtaining other types of certification. This includes experience in obtaining ISO-approved certificates, which may be an important driver thanks to the learning process already undergone in applying for previous certification from this international organization or others. The total number of ISO 9001 certifications in each sector, certifying quality management systems, is specifically included.

*Internationalization* refers to a sector's capacity to sell on international markets. This driver is measured using a variable that captures the destination of exports: the European Union and the rest of the world. Access to export markets has been shown to affect the environmental commitment at the firm level and sectoral level (Bodas Freitas & Iizuka, 2012).

A set of control variables, Z, is also included in this specification as control. These are drivers identified in the literature as being determinants of environmental certification at the industry level. First, we use the volume of sales to control for demand. Second, we include firm characteristics – albeit at the industry level – that may be drivers of certification, such as the average firm size. We also consider the role of management as a driver of environmental certification, and therefore include three types of environmental investment and pollution prevention measures. These variables – R&D expenditure for environmental purposes, investment in end-of-pipe solutions, and investment in the production process – capture the environmental strategies firms develop in relation to environmental certification. End-of-pipe investment refers to technological solutions that firms incorporate into existing manufacturing processes but are not essential parts of them, while investments in production processes correspond to new, or substantially modified, production facilities that represent an integral part of the production process aimed at reducing pollution (Demirel & Kesidou, 2011).

Finally, we consider random time-invariant characteristics $\mu_i$ and time-effect dummies to control for macroeconomic effects (e.g. the business cycle) common to all industries.

## 4. RESULTS AND DISCUSSION

Table 4 presents the results of the econometric analysis regarding the main drivers of ISO 14001. First, Model 2 shows that the coefficient of the variable *pollution taxes* is positive and statistically significant ($\beta = 0.226$, $p < 0.01$), which confirms H1. Accordingly, this indicates that sectors operating under stricter environmental policy tend to be more frequent adopters of eco-certification. Coercive pressures force polluting sectors to comply with norms and regulations, and, in this instance, to adopt organizational eco-innovations.

Second, the estimations in Model 3 show that the effect of the *ISO 9001* upon ISO 14001 is clearly positive and statistically significant ($\beta = 0.540$, $p < 0.01$). On these grounds, we can conclude that the results uphold H2: sectors where the adoption of ISO 9001 is greatest tend to be more sustainable. This reflects the fact that firms in these sectors have already developed tacit capabilities and routines across the organization and have embraced a systematic process of organizational change based on monitoring, assessment and action which is very similar to that required by ISO 14001. As Zhu, Cordeiro, & Sarkis (2013) found regarding the path-dependent character of organizational learning in Chinese firms in adopting ISO 14001 with prior experience in ISO 9001, we also confirm that the existence of prior capabilities in obtaining quality certification constitutes experience in adopting environmental certifications.

Third, Model 4 shows that variable *exports* exert a positive and statistically significant effect upon ISO 14001 ($\beta = 1.445$, $p < 0.1$). This confirms H3: internationalization drives sectoral diffusion of environmental certifications. Environmental certification is more prevalent in sectors that are export oriented.

Finally, the results in Model 5, where all the variables are included, show that the coefficients of ISO 9001 and internationalization are positive and statistically significant. Yet, surprisingly, the variable capturing the institutional pressures, *pollution taxes,* loses its significance. A plausible explanation for this new finding might be that international pressures substitute for national institutional pressures. It also shows that international pressures are more powerful than national forces in driving the adoption of environmental certifications across sectors.

Our results regarding the control variables show that firm size is a major driver of ISO 14001 adoption. As the literature in this field emphasizes, a minimum size threshold has to be reached in order to be able to implement an EMS. In contrast, most of the other control variables were found not to be significant.

[Insert Table 4 around here]

To check the robustness of our results we have carried out some complementary estimations (Table 5). First, we have created a new dependent variable, adding ISO and EMAS certifications. The results confirm our hypotheses regarding the influence of ISO 9001 and internationalization pressures in obtaining eco-certifications. Second, potential reverse causality might be a problem with some variables, such as in the case of exports and ISO 9001. To minimize the endogeneity concerns, we have carried out two estimations using lags of ISO 9001 and exports respectively (Models 2 and 3). The results remain consistent: both the lag of ISO 9001 and the lag of exports are positive and statistically significant.

Finally, we have used random models to carry out our estimations. Some of the independent variables of our model show very little variation over time and, in this situation, fixed effects models do not perform well and can lead to imprecise estimates. Nevertheless, there is still the problem with the random effects model that some of the regressors may be correlated with the error term. To deal with that we have included in the robustness section an estimation using the endogeneity-robust approach developed by Mundlak (1978). Mundlak (1978) suggested that one way to overcome endogeneity is by including the means of the regressors in the equation. Again, the results remain unchanged and confirm our hypotheses.

[Insert Table 5 around here]

## 5. CONCLUSIONS

The aim of this analysis has been to contribute to the literature on eco-innovation by explaining the drivers of organizational eco-innovations across sectors using ISO 14001 certification, one of the main reference standards for EMSs. Prior theoretical and empirical studies have shown the need to take a broad range of firm characteristics and motivations into account – internal as well as external – when examining the factors that drive the diffusion of ISO 14001.

We have constructed a panel database with information from several industry sources concerning ISO certification and innovation and including details about prevailing economic and environmental characteristics in order to examine these determinants in Spain. Although the limitations of using industry-level data as opposed to firm-level data are well known, this has enabled us to include a broad range of variables that the literature identifies as potential drivers of environmental certification. We have been able to include all industrial sectors in the estimations with this information, whereas most empirical studies limit themselves to either one or only a few sectors. Using this database, we have carried out an empirical analysis of panel data for 16 manufacturing sectors in Spain for the period 2009–2014.

The analysis has some limitations and further research is required. For example, it would be interesting to examine the time effects of some variables in greater detail, together with the short- and long-term effects of specific policy instruments and regulations.

Having said that, the estimations provide a considerable amount of relevant information regarding the factors that drive ISO 14001 certification, which, in turn, reinforces sectoral sustainability. Indeed, this paper contributes to the eco-innovation literature, in general, and to EMS research, in particular, by generating and empirically testing a conceptual framework that identifies the factors that underpin variations in the diffusion of ISO 14001 across sectors. Our empirical results demonstrate that coercive institutional pressures explain differences in the patterns of EMS certification. Highly polluting industries seek to certify their EMSs so as to comply with current or future environmental regulations. In addition, we show that the previous adoption of highly institutionalized management systems, such as ISO 9001, facilitates the adoption of EMSs across industries owing to resource complementarities. Finally, our findings indicate that industries most exposed to international competition are more likely to adopt EMSs so as to signal their environmental credentials to international markets.

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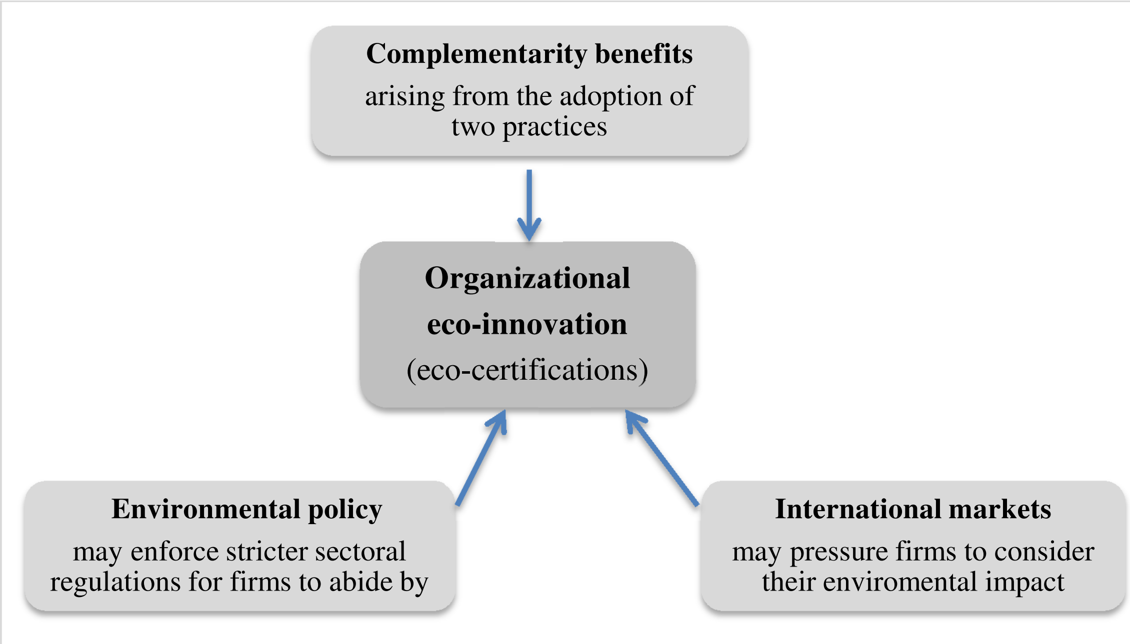


**FIGURE 1** Conceptual framework: Drivers of organizational eco-innovation

*Source*. Authors'.

**TABLE 1** The variables: Definitions and sources

| Variables | Definitions | Source |
|---|---|---|
| ISO 14001 | Number of ISO 14001 certificates per industry, in logs | International Organization for Standardization |
| EMAS | Number of EMAS certificates per industry, in logs | European Commission. EU EMAS REGISTER |
| Sales | Annual turnover, in logs | Industrial Companies Survey, National Statistics Institute of Spain (INE) |
| Size | Average size in the sector (employees/firms) | Industrial Companies Survey, INE |
| Environmental R&D | Business R&D expenditure on the control and care of the environment, in logs | Statistics on R&D activities, INE |
| Investment in production process | Investment in environmental protection (integrated equipment and facilities), in logs | Environmental protection activities survey, INE |
| Investment in end-of-pipe | Investment in environmental protection (independent equipment and facilities), in logs | Environmental protection activities survey, INE |
| IS09001 | Number of ISO 9001 certifications per industry, in logs | International Organization for Standardization |
| Pollution taxes | Taxes on pollution and resources, in logs | Environmental tax account, INE |
| Exports to EU and to the rest of the world | Percentage of exports per industry | Industrial Companies Survey, INE |
| HHI | Herfindahl-Hirschman concentration index | Technological Innovation Panel, INE |

*Note*. Information covers the period 2009–2014 and refers to 16 Spanish manufacturing industries.

**TABLE 2** Descriptive statistics

| **Variables** | **Mean** | **Std Dev** | **Min** | **Max** |
|---|---|---|---|---|
| ISO 14001 | 5.323 | 1.176 | 2.97 | 7.045 |
| EMAS | 1.547 | 0.886 | 0 | 2.944 |
| Sales | 16.760 | 0.932 | 15.069 | 18.479 |
| Size | 88.33 | 238.11 | 4.473 | 1139.06 |
| Investment in environmental R&D | 12.424 | 1.328 | 7.815 | 15.078 |
| Exports | 0.347 | 0.137 | 0.0114 | 0.664 |
| Investment in production process | 15.298 | 1.693 | 10.561 | 17.986 |
| Investment in end-of-pipe solutions | 16.031 | 1.665 | 11.804 | 18.596 |
| ISO 9001 | 6.381 | 1.465 | 2.303 | 8.964 |
| Pollution taxes | 1.064 | 1.043 | 0 | 4.579 |
| HHI | 643,96 | 707,70 | 23,67 | 2880,54 |

**TABLE 3** Percentage of firms with EMSs: 2009–2014

| **Sector** | **ISO 14001 (%)** | **EMAS (%)** |
|---|---|---|
| Mining and quarrying (CNAE 05, 06, 07, 08, 09) | 6.0 | 0.01 |
| Coke and refined petroleum products (CNAE 19) | 100.0 | 10.70 |
| Food products, beverages and tobacco (CNAE 10, 11, 12) | 3.5 | 0.03 |
| Textiles and wearing apparel (CNAE 13, 14) | 0.8 | 0.06 |
| Leather and related products (CNAE 15) | 0.9 | 0.03 |
| Wood and products of wood and cork (CNAE 16) | 1.8 | 0.01 |
| Paper and paper products, printing and reproduction of recorded media (CNAE 17- 18) | 3.5 | 0.14 |
| Chemicals and chemical products (CNAE 20) | 20.0 | 0.65 |
| Basic pharmaceutical products and pharmaceutical preparations (CNAE 21) | 19.4 | 2.50 |
| Rubber and plastic products (CNAE 22) | 8.9 | 0.15 |
| Other nonmetallic mineral products (CNAE 23) | 4.1 | 0.07 |
| Basic metals and fabricated metal products, except machinery and equipment (CNAE 24, 25) | 3.3 | 0.03 |
| Computer, electronic, and optical products and electrical equipment (CNAE 26, 27) | 14.5 | 0.20 |
| Machinery and equipment. (CNAE 28) | 11.7 | 0.08 |
| Motor vehicles, trailers and semi-trailers and other transport equipment (CNAE 29, 30) | 16.6 | 0.38 |
| Furniture and other manufacturing activities (CNAE 31, 32) | 1.4 | 0.01 |

*Note*. In the case of EMAS, the period is 2008-2014. CNAE is the Spanish Classification of Economic Activities adhering to the same rules as NACE Rev. 2.

**TABLE 4** Drivers of environmental certifications

| | (1)<br>Model 1 | (2)<br>Model 2 | (3)<br>Model 3 | (4)<br>Model 4 | (5)<br>Model 5 |
|---|---|---|---|---|---|
| Dep. variable: | | | ISO 14001 | | |
| Sales | 0.156 | -0.202 | 0.044 | -0.215 | -0.572* |
| | (0.235) | (0.228) | (0.217) | (0.275) | (0.280) |
| Size | 0.002*** | 0.002*** | 0.002*** | 0.012*** | 0.017*** |
| | (0.000) | (0.000) | (0.000) | (0.004) | (0.003) |
| Invest env. R&D | -0.112 | -0.011 | -0.098** | -0.024 | -0.026 |
| | (0.067) | (0.027) | (0.040) | (0.039) | (0.035) |
| Invest prod. process | -0.073 | 0.066** | -0.078 | 0.024 | 0.078 |
| | (0.075) | (0.029) | (0.057) | (0.043) | (0.050) |
| Invest end-of-pipe | 0.003 | -0.037 | 0.002 | -0.002 | 0.012 |
| | (0.043) | (0.027) | (0.029) | (0.042) | (0.027) |
| Pollution taxes | | 0.226*** | | | 0.197 |
| | | (0.060) | | | (0.128) |
| ISO 9001 | | | 0.540*** | | 0.436* |
| | | | (0.101) | | (0.233) |
| Exports | | | | 1.445* | 1.718*** |
| | | | | (0.702) | (0.514) |
| Constant | 5.113 | 8.420** | 3.368 | 8.602* | 10.389* |
| | (3.576) | (3.604) | (3.284) | (4.400) | (5.060) |
| time variables | yes | yes | yes | yes | yes |
| Observations | 96 | 74 | 96 | 66 | 56 |
| R-squared | 0.602 | 0.720 | 0.734 | 0.782 | 0.832 |
| Number of ID | 16 | 13 | 16 | 11 | 10 |

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

**TABLE 5** Robustness diagnosis

| | (Model 1) ISO+EMAS | (Model 2) Lag of ISO 9001 | (Model 3) Lag of exports | (Model 4) Rivals IHH | (Model 5) Mundlak |
|---|---|---|---|---|---|
| Sales | -0.550* | -0.480* | -0.632** | -0.535* | -0.500** |
| | (0.271) | (0.253) | (0.266) | (0.288) | (0.212) |
| Size | 0.016*** | 0.021*** | 0.017*** | 0.019*** | 0.018*** |
| | (0.003) | (0.004) | (0.003) | (0.005) | (0.006) |
| Invest in env. R&D | -0.027 | 0.000 | -0.030 | -0.020 | -0.028 |
| | (0.034) | (0.029) | (0.033) | (0.029) | (0.046) |
| Invest prod. process | 0.075 | 0.086 | 0.088 | 0.078 | 0.083** |
| | (0.050) | (0.068) | (0.050) | (0.052) | (0.041) |
| Invest end-of-pipe | 0.010 | 0.003 | 0.021 | 0.006 | 0.019 |
| | (0.027) | (0.028) | (0.030) | (0.026) | (0.039) |
| Pollution taxes | 0.189 | 0.151 | 0.216* | 0.189 | 0.204** |
| | (0.122) | (0.127) | (0.116) | (0.114) | (0.091) |
| ISO 9001 | 0.425* | | 0.437 | 0.406 | 0.443*** |
| | (0.228) | | (0.239) | (0.238) | (0.068) |
| Exports | 1.612** | 2.216 | | 1.704** | 2.555*** |
| | (0.506) | (1.403) | | (0.619) | (0.674) |
| Lag ISO 9001 | | 0.505* | | | |
| | | (0.273) | | | |
| Lag of exports | | | 2.958** | | |
| | | | (1.000) | | |
| HHI | | | | 0.000 | |
| | | | | (0.000) | |
| M(prod proc) | | | | | -0.306*** |
| | | | | | (0.072) |
| M(end-of-pipe) | | | | | 0.112 |
| | | | | | (0.083) |
| M(env R&D) | | | | | 0.065 |
| | | | | | (0.065) |
| M(pollution) | | | | | 0.243** |
| | | | | | (0.109) |
| M(sales) | | | | | 0.700*** |
| | | | | | (0.225) |
| M(size) | | | | | -0.031*** |
| | | | | | (0.007) |
| Constant | 10.268* | 7.598 | 10.808* | 9.857* | -0.516 |
| | (4.893) | (6.653) | (4.803) | (5.363) | (0.968) |
| Time variables | yes | yes | yes | yes | yes |
| Observations | 56 | 48 | 56 | 56 | 56 |
| R-squared | 0.829 | 0.835 | 0.849 | 0.834 | |
| Number of ID | 10 | 10 | 10 | 10 | 10 |

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

**Appendix**

**TABLE 1** Correlation matrix

| | ISO 14001 | EMAS | Sales | Size | Invest R&D | Invest prod. proc. | Invest end-of-pipe | Pollution taxes | ISO 9001 | Exports |
|---|---|---|---|---|---|---|---|---|---|---|
| EMAS | 0.579* | | | | | | | | | |
| Sales | 0.493* | 0.571* | | | | | | | | |
| Size | -0533* | -0.216* | 0.262* | | | | | | | |
| Invest R&D | 0.562* | 0.554* | 0.696* | 0.039 | | | | | | |
| Invest prod. proc, | 0.242* | 0.441* | 0.601* | 0.336* | 0.451* | | | | | |
| Invest end-of-pipe | 0.379* | 0.552* | 0.813* | 0.369* | 0.613* | 0.833* | | | | |
| Pollution taxes | -0.189 | 0.123 | -0.083 | 0.084 | -0.063 | 0.549* | 0.191 | | | |
| ISO 9001 | 0.962* | 0.534* | 0.373* | -0.647* | 0.480* | 0.162 | 0.264* | -0.186 | | |
| Exports | 0.060 | 0.370* | 0.528* | 0.636* | 0.542* | 0.000 | 0.054 | -0.133 | -0.030 | |
| HHI | -0.258* | -0.005 | 0.126 | 0.351* | -0.004 | 0.038 | 0.183 | -0.425* | -0.274* | -0.254* |

*p<0.5