



Research article

Determinants for the adoption of ISO 14001: the case of Portuguese firms

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Abstract: Climate change and the consequent increase in society's environmental awareness have triggered new forms of pressure on companies and the way they face environmental sustainability. Hence, either by legal imposition or by other types of pressures, companies must incorporate the environmental impact of their activities into their responsibilities, without compromising their financial viability. Environmental certification is a common procedure for firms to improve their environmental performance, as well as increase their reputation and image. Notwithstanding, determinants for environmental certification are still poorly understood. Therefore, the present study aims to assess, from a sample of 1,917 Portuguese companies of various sectors and dimensions, the influence of some factors on the probability of a firm adopting the ISO 14001 certification. Results showed that the different variables used as measures of profitability of the firm have a positive impact on its probability of adopting ISO 14001. Other factors with the same effect include the participation of the firm in the stock market and the firm's size. This can be justified by a greater need for large firms to improve their reputation or to have access to some markets where this kind of certification is an obligation. However, it is also possible to observe a certain variation in results depending on the measures of profitability used. Another conclusion is that the fact that a firm is an exporter does not influence its probability to be certified in any of the specifications, something contrary to what has been found in the literature.

Keywords: environmental sustainability; environmental certification; ISO 14001; firms' behavior; binary logit estimation

JEL Codes: D22, O30, Q50

1. Introduction

1.1. General context

Climate change has put pressure on policymakers and businesses to change behavior. In addition, with globalization, the competitiveness of companies is achieved mainly through the use of more advanced technologies and improved input using methods (Porter and Vanderlinde, 1995). Thus, companies need to be able to innovate quickly and achieve more productive use of resources, whether natural, physical, human and capital. In the context described, environmental progress is of great importance. It requires companies to call for increased resource productivity (Porter and Vanderlinde, 1995) and to take measures to improve their environmental performance, either under legislation, that is increasingly restrictive of negative impacts on the environment, or pressure from their stakeholders. At the same time, companies must be able to maintain their economic viability to be able to continue their activities, especially in very competitive markets.

One of the ways to evaluate the environmental performance of companies is through their environmental certification. There are essentially two voluntary regulations that define the requirements for the certification of the environmental management system, ISO 14001 of the *International Standard Organization* and the *European Union's Eco-Management and Audit Scheme* (EMAS).

The method of implementation of ISO 14001 is based on the PDCA - *Plan-Do-Control-Act* cycle and the main requirements defined by the standard and necessary to obtain certification are: (i) develop environmental policy and commit to continuous improvement; (ii) identify all activities that have an impact on the environment and define those that have the greatest impact; (iii) establish environmental objectives and targets; (iv) develop processes to control environmental performance and measure impact on the environment; (v) promote the training of employees in environmental processes; (vi) ensure compliance with environmental regulations and laws; (vii) conduct internal hearings; (viii) and periodically review the environmental management system (Sartor et al., 2019a). ISO 14001 certification is not mandatory, and companies can adopt the standard without certification, however, certification is a way to signal to stakeholders that the standard is being implemented appropriately.

1.2. Benefits of ISO 14001 certification

ISO 14001 allows companies to acquire, integrate and change environmental-oriented resources, develop tacit and socially complex environmental capabilities, and ultimately gain a long-term sustainable competitive advantage (De Jong et al., 2014). This certification is based on management processes instead of performance and is applicable to all types of organizations (Wu et al., 2007). According to ISO (2015), the main benefits reported by companies that follow ISO 14001 are compliance with current and future regulatory requirements; increased leadership involvement and employee commitment; better reputation for the organization and stakeholder trust due to strategic communication; compliance with strategic objectives due to the incorporation of environmental impacts on the management of the business; increased efficiency and reduced costs, which allows them to obtain competitive and financial advantages; an incentive to improve the environmental performance of suppliers by their integration into business organization systems. Sartor et al. (2019a) list the following results, referred to in the literature, in the performance of companies resulting from ISO 14001 certification: increases in productivity and control; reduction of waste and consumption of

resources and optimization of the use of raw materials; decrease in the frequency of inspections; better quality of products or services; increased flexibility; better health and safety conditions at the workplace; positive long-term reaction of financial markets; investment in R&D and more efficient innovation; increased profitability and sales of the company; increased reputation and business image; increased customer satisfaction; greater punctuality in delivery and reduction in delivery times; better compliance with laws and regulations; increased awareness and morale of employees; capacity to reduce environmental impact; dissemination of environmental practices along the supply chain; improving relationships with communities and authorities; implementation of other environmental practices. From an operational perspective, the adoption of ISO 14001 and its practices leads to a substantial increase in the operational performance of companies in terms of employee productivity, the efficiency of production cost, operating cycle and asset profitability (Treacy et al., 2019). Furthermore, the certification ISO 14001 increases the environmental legitimacy of firms (Wu et al., 2007). The temporal evaluation shows that operational performance increases over time. According to Cushing et al. (2005) ISO 14001 is also a management tool to help companies integrate new environmental policies into their operations and to identify and develop plans for dealing with environmental regulatory violations. The authors also point to benefits such as cost savings, improved regulatory compliance, reduced resource use, pollution reduction, new procedures, infrastructure investment, and diffusion. Furthermore, in a systematic review of this topic, Camilleri et al. (2022) concluded that ISO 14001 certification increased operational efficiencies of firms, due to more efficient resource use and waste management. Also, image benefits were identified.

1.3. Difficulties in ISO 14001 certification

However, the adoption of ISO 14001 certification also faces some difficulties. The main difficulties identified in the literature are the risk of disseminating confidential information; the reduction of productivity resulting from the increase in administrative tasks; the formal implementation of ISO 14001 by companies to obtain only their commercial value instead of improving company practices, thus limiting the effectiveness of the standard; the high cost of certification, including in particular the certification body, the time spent by the company in the certification process and the training of employees; the difficulty of evaluating the results of the certification, being difficult to quantify; the risk of underestimating the necessary resources; the time spent on frequent control visits; inadequate technical competence of the auditors; employees commitment (Sartor et al., 2019b).

This problem is part of the debate on the relationship between the environmental and financial performance of companies. Until the 1990s it was commonly accepted that investing in increased environmental performance harmed businesses (Melnyk et al., 2003). It was believed that this investment increased delivery times, decreased the quality of products and/or services or increased costs, resulting in reduced profits and revenues of shareholders. Only later did companies begin to face the need to reduce pollution and improve environmental management (Melnyk et al., 2003). The so-called “Porter hypothesis” contributed decisively for this change of perspective. This hypothesis argued that environmental regulatory rigor leads to environmentally sustainable innovation, allowing companies to achieve the dual objective of environmental protection and increased business performance (Hojnik & Ruzzier, 2017). Porter and Van der Linde (1991) stated that the static and narrow view of competition and sources of prosperity led to the construction of a false dichotomy between environmental protection and economic competitiveness. On the other hand, Camilleri et al.

(2022) concluded that there are some potential drawbacks to ISO 14001 certification such as high certification costs, time constraints, and increased bureaucracy or difficulties to inform employees of the necessary procedures.

In the development of this debate, there is a great diversity of studies, with different approaches, different objectives and different conclusions, sometimes apparently opposed. This is due to the great heterogeneity of variables used and different time horizons. Some studies find a positive relationship between environmental performance and the financial performance of companies (Arocena et al., 2021; De Jong et al., 2014; Ferron et al., 2012; Heras-Saizarbitoria et al., 2011; Hojnik & Ruzzier, 2017; Horvathova, 2012; Luan et al., 2016; Miroshnychenko et al., 2017; Nishitani, 2011; Ong et al., 2016; Treacy et al., 2019), others point to a negative relationship (Riaz & Saeed, 2020; Robaina & Madaleno, 2020) and there are also studies that do not find a statistically significant relationship between environmental performance and the financial performance of companies (Sarumpaet, 2005).

Another relevant issue for this debate is the possible existence of a double-direction effect (Hang et al., 2019). That is, it is not just an environmental certification that influences the financial performance of companies, but also the characteristics of these firms that influence the probability of being certified. In this context, it could be argued that financially sound companies, with more resources available and with international image concerns, will be more likely to be certified. Given that this certification scheme is voluntary, it is relevant to properly understand the determinants of the firms decision to adopt ISO 14001. As referred by Wu et al. (2007), several empirical studies have examined these determinants for voluntary environmental schemes (Henriques and Sadorsky, 1996; DeCanio and Watkins, 1998; Nakamura et al., 2001). However, these analyses are not specific for ISO 14001 and should be further developed. This branch of the literature is not as developed as the previous one.

1.4. Research contribution

The aim of this study is to contribute to previous literature on the determinants of ISO 14001 adoption. With this intention, we examine in great detail the influence of some factors on the probability of being certified with ISO 14001. We focus on a very extensive number of Portuguese firms (1,917). Portugal is an interesting case study given its characteristics. It is a small open economy, very dependent on exports. Hence, the study of this country is relevant because firms are subject to strong international competition. Most exports are directed to European countries where environmental concerns are high.

This study contributes to the literature for two main reasons. Firstly, to our knowledge this type of study has never been performed in Portugal. Secondly, we compare the effects of the determinants for the adoption of ISO 14001 taking into consideration different performance and profitability indicators as dependent variables. This consideration may be of interest since not all profitability measures may be equal, some may increase the amount of monetary resources available for the firm to invest, while others may, for example, benefit shareholders. As far as we know, this has also never been done in the literature. It should be noted that in the Portuguese case, Robaina and Madaleno (2020) investigated the relationship between the reduction of emissions and the financial performance of Portuguese companies. The authors showed that since pollution is positively related to the financial performance of companies and because increased environmental performance entails additional costs, companies tend to deprecate these investments by giving up greater environmental performance.

The structure of the article is as follows, after this introduction we provide some relevant literature on the topic; afterward in section 3 we discuss the methodology and data; section 4 depicts the results and finally, section 5 concludes the paper.

2. Literature

2.1. *Environmental management systems*

An environmental management system helps companies to identify, manage, evaluate and control their environmental impact holistically (ISO, 2015) improving their environmental performance (Sartor et al., 2019a) and Melnyk et al. (2003) report that the environmental management system also involves a system and a formal database integrating procedures and processes for staff training, monitoring, summary and publication of information on the environmental performance of companies to internal and external stakeholders. Internal environmental information focuses on the method, control and minimization of pollution and waste, training, communication to top management, and setting objectives; simultaneously, external communication is made in the annual reports focusing on the companys results, with the aim of improving the companys image. Thus, adopting an environmental management system implies controlling a large number of production processes and implementing a pollution, energy and waste management system (Frondel et al., 2018). DAdamo (2022) also emphasizes the broad advantages of improved sustainability corporate reports, including, for example, stakeholder involvement.

In 1996, the International Organization for Standardization (ISO) adopted a new international standard for the organizations environmental management system, ISO 14001, with the intention of raising expectations for environmental practices worldwide and to facilitate trade and reduce trade barriers. This certification was a way of standardizing the criteria of environmental management systems, which would otherwise be diverse and sometimes conflicting between countries (Melnyk et al., 2003). ISO 14001 is based on processes, not results, and is a tool to guide managers in their efforts to capitalize on pollution reduction costs (Melnyk et al., 2003). ISO 14001 is therefore an internationally accepted standard that defines the requirements for an environmental management system, helping companies improve their environmental performance through more efficient use of resources and reducing waste providing greater competitive advantages and increased stakeholder confidence (ISO, 2015).

2.2. *Factors determining the ISO 14001 certification*

One of the first factors encountered in the literature is the financial performance of the firm. Heras-Saizarbitoria et al. (2011) explored the relationship between ISO 14001 certification and the financial performance of firms to understand whether the best performance is due to certification, or whether the companies with the best financial performance are the ones seeking certification. The authors concluded that, in general, there is a positive relationship between the best environmental performance and the increase in the financial performance of companies, but also that there is a greater propensity to develop environmental initiatives, such as the adoption of ISO 14001, by companies that have an above-average financial performance. At the same time, as Miroshnychenko et al. (2017) indicate, the adoption of ISO 14001 may require large investments and it is an expensive and time-

consuming process (Ong et al. 2016). Thus, the companies that adopt the standard are well-established companies, with good performances and stable growth. According to Ong et al. (2016) there is a double-meaning effect, because ISO 14001 certification results in the best financial performance of companies, and on the other hand, the good financial performance of companies encourages them to adopt ISO 14001, which is in line with the conclusions of Heras-Saizarbitoria et al. (2011).

Another relevant factor, related to the financial performance of firms, may be the differentiated benefit that firms take from the certification. For example, Zhang et al. (2021) analyzed the impact of ISO 14001 on the environmental performance of Chinese companies from highly polluting industries registered on the China stock exchange. The authors concluded that the higher the financial performance of companies, the greater the effect of ISO 14001 certification on their environmental performance. Thus, companies with better financial capacity benefit more from the certification, which increases the incentive to adopt certification. Similarly, Hang et al. (2019) show that the financial capacity of companies causes better environmental performance in the short term (period of one year).

Another factor referred to in the literature as relevant to the certification decision would be the type of company, whether in relation to their size or in relation to the sector in which they operate. According to ISO (2015), ISO 14001 is adjusted to any type of company it will be important to assess whether these types of factors influence the probability of adoption of the certification. Also, Sartor et al. (2019a) report that ISO 14001 is the norm with great generality and can be applied to different sectors of activity. This is because the standard does not impose specific objectives or strategies, allowing organizations to set their own objectives and define their performance measures depending on the type of industry and specific needs. The results obtained by Nishitani (2011) indicate that environmental certification could be more beneficial for more polluting and more energy-intensive industries. Thus, these firms may be the ones with the greatest incentive to adopt ISO 14001. Sarumpaet (2005) and Hartmann et al. (1997) show that the environmental performance of companies is significantly related to the size of these companies. Similarly, Arocena et al. (2021) showed that the increase in the profitability of companies following the adoption of ISO 14001 is greater in larger companies. Nakamura et al. (2001) refer that certification has high fixed costs and that they are more significant for small enterprises.

In addition, certification can be an important factor for companies that care about their image, reputation or signaling to stakeholders (Riaz and Saeed, 2020). Although certification is not mandatory, it will allow signaling to the market that the company has a better environmental performance. According to Frondel et al. (2018), companies that adopt an environmental management system without certification, have no impact on the performance of their business, while certification has a positive impact on the financial performance of companies. Thus, if this signaling effect is sufficiently important, companies with greater concern for their reputation will be more likely to adopt certification. In line with this, Reis et al. (2018) concluded that generally certified companies are well-established companies in the market and with economic power, but still seek certification as a way to attract new customers, new investors and improve their image and reputation.

The importance of the signaling effect contributes a greater or lesser environmental awareness of the public. For example, Ong et al. (2016) concluded that ISO 14001 enhances consumer preference, indicating greater environmental awareness. On the other hand, it also has a positive effect on the side of investors, as it is increasingly frequent that investors believe that companies that show greater environmental concerns will be more sustainable than their counterparts. Ong et al. (2016) also mention that companies with ISO 14001 certification benefit from better reputation and public image,

and a more developed environmental management system that allows a higher cost reduction for companies without certification. Additionally, Arocena et al. (2021) showed that the economic impact of the adoption of ISO 14001 is greater in countries with greater environmental awareness.

Related to the effect of reputation, an important factor that may affect the decision to be certified is its presence in the stock market. These firms require shareholders to invest in their capital, therefore they need a strong and trustworthy reputation. For example, Przychodzen and Przychodzen (2015) show that environmental innovations have a positive financial impact on companies traded in the stock market in Poland and Hungary. Also, Sarumpaet (2005) shows that the environmental performance of companies is significantly related to their stock exchange listings. Ferron et al. (2012) indicate that certification is used by listed companies as a signal to the market, reducing the asymmetry of information between companies and stakeholders, thereby increasing demand for their products and services. Also focusing on listed companies, Riaz and Saeed (2020) report that there are several studies that point to a positive impact on the market by the adoption of ISO 14001 certification, because the certification is perceived by the market as a commitment of the company to the environment and with greater operational efficiencies. However, this impact varies with the countries under study being more important in more developed countries that value environmental performance more.

Also related to the topic of reputation, another factor that may affect the incentive to environmental certification is the company's presence in the international market. In particular, an exporting company may want to be certified to increase its legitimacy and external reputation (Wu et al., 2007), thus responding to international pressures (Darnall et al., 2008). The results obtained by Nishitani (2011) for a number of Japanese companies also show that certification increases the demand of companies, especially exporters. This indicates the importance of the reputation factor in international competition. Simultaneously, Brunnermeier and Cohen (2003) point to the fact that environmental innovation occurs more frequently in companies that compete internationally. Luan et al. (2016) also show that the level of internationalization is significantly relevant to the demand and adoption of green activities.

2.3. Similar studies

Some studies have performed a similar analysis to the one proposed in this article, analyzing the determinants that affects the probability to adopt ISO 14001 certification.

Nakamura (2001) studied the determinants of the ISO 14001 certification in Japan using a sample of 193 firms and found that environmental values, beliefs, and attitudes of managers were the most important factors. The size of the firm and the fact that the firm was an exporter also increased the probability of certification. Christmann and Taylor (2001) studied the determinants of self-environmental regulation through voluntary certification in China. The study concluded that multinational firms, especially the ones exporting to countries with higher environmental concerns were the ones with a high probability to be certified. Other factors affecting this probability include, for example, previous certifications such as ISO 9000.

Cushing et al. (2005) performed a study of the determinants for the adoption of ISO 14001 for China and concluded that the main factors influencing adoption include governmental intervention through sponsored environmental projects or regulations, the internationalization of firms, transnational corporate policy, potential economic and environmental benefits, and particular interests of top management. Also for China, Zeng et al (2005), concluded that the main motivation for firms to

adopt ISO 14001 certification was the need to enter international markets due to image/reputation concerns. Other relevant issues included the environmental conscience of leaders, and legal requisites. Wu et al. (2007) studied the determinants of Taiwanese companies adopting ISO 14001, concluding that export orientation, state subsidies, R&D investment and the location of companies in industrial technology zones have a positive impact on companies decision adopting ISO 14001 certification. Nishitani (2009) performed the study for a set of Japanese firms and concluded that the environmental preferences of stakeholders, financial flexibility, economic performance, size, and exporting profile of firms were important determinants. Fikru (2014) studied the case of Ethiopia concluding that the determining factors of the adoption of international certification by companies include the pressures of trade and international laws, the “domestic” pressures and the capacities of companies, the profile of managers and the seniority of the company. Sartor et al. (2019a) state that the adoption of ISO 14001 certification is motivated by the increase in the companys image; for ethical reasons and environmental concerns; to respond to customer pressure, especially when customers are large companies with a strong weight in the supply chain; to respond to environmental legal requirements; to benefit from “green” incentives; to increase the efficiency of the company; to reduce information asymmetries between suppliers and buyers; and to reduce the release of toxins. Sartor et al. (2019b) identify in the literature a few more factors that can influence the adoption of the standard, including the prior presence of an environmental management system; the size of companies, with the largest companies being more likely to adopt ISO 14001; strategic proactivity, i.e., the tendency to implement the most modern and advanced practices; the economic development of the regions companys head; the density of certified companies geographically close; the level of diffusion of ISO 9001 (a normal quality certification) in the country.

3. Materials and methods

3.1. Specification

In this study, we follow a methodology like the one in Wu et al. (2007) to estimate the determinants of ISO 14001 adoption. The econometric specification is defined as follows in Equation 1:

$$P(y_{it} = 1 | \mathbf{X}_{it}) = \Phi(\eta_i + X_{it}\bar{\beta}) \quad (1)$$

Where the dependent variable y_{it} equals 1 if the firm has the ISO 14001 certification at time t , and 0 if the firm is not certified. The vector \mathbf{X}_{it} contains the explanatory variables including: some dummies, if the firm is listed on the Stock Exchange and if it is an exporting firm, for the firm sector and firm dimension; Return on Equity; Assets Profitability; Gross Value Added and Assets. Meanwhile Φ is the cumulative probability of a normal distribution and an empirical specification of the above equation is a Binary Random-Effects¹ Logit Model with Panel Data.

¹ In order to verify the model that best fits the study in question, the Hausman test was carried out. According to the results obtained, it was possible to conclude that the random-effects model is the most suitable for the study in question.

3.2. Data sources

In order to investigate the factors leading a firm to adopt ISO 14001 certification, panel sample data was collected using variables from secondary sources of companies of different sizes and industrial sectors, as recommended by Hillary (2004), using the Sistema de Análise de Balanços Ibéricos (SABI) database for this purpose.

For the selection of the sample of companies with ISO 14001 certification, data from the IPAC (Instituto Português de Acreditação) database, available from 2010 to 2020, of firms with accredited certification were used. The research strategy was to verify if the firm was active, and with values for the entire period from 2010 to 2020 for the variables considered relevant for the study in question.

From a universe of 1235 companies certified with ISO 14001 in 2020 contained in the IPAC database, 959 companies were found that met the defined criteria. Then, for each sector of activity, the same number of non-certified companies were randomly selected, and when there were not enough firms, all available firms were selected, thus resulting in a sample of 958 non-certified firms in 2020, translating into a sample of 1,917 firms.

3.3 Variable measurement

The dependent variable in this study is the binary variable, *isso certification*, which represents whether a firm is ISO certified or not, *isso* ISO certification is coded 1 for a firm adopting ISO 14001 certification, and 0 otherwise.

The independent variables considered are defined below:

The dummy variable Stock Exchange (Stock) indicates if the firm is listed on the Stock Exchange, and is coded as 1 if yes, and 0 otherwise. Regarding this variable, the research hypothesis is:

[H1] The participation of a firm in the stock Exchange increases its probability to have ISO 14001 certification.

This hypothesis would be justified by the fact that a firm in the stock exchange has higher concerns with its image. Firms with better reputation can be further valued in the stock market.

As Luan et al. (2016), Nishitani (2011) and Sarumpaet (2005), and because exporting companies are subject to international pressures that companies that operate exclusively in the domestic market do not face, the companies opening to the outside, is controlled, using a dummy variable – Exporter – coded as 1 if is an exporter firm, and 0 otherwise. When it comes to this variable the research hypothesis is:

[H2] A firm that exports has a higher probability of having ISO 14001 certification.

The justification for this hypothesis is very similar to the one for [H1] since exporting companies need to have a better image and reputation in international markets, which often are more demanding and competitive.

To assess whether the estimates are affected by different measures of profitability, this study considers three different variables to estimate the effect of profit on ISO 14001 adoption. First, to represent the company's economic performance the logarithm of the Gross Value Added (GVA) of the company was used for each year in thousands of euros. Then, we used the logarithm of the Total Assets of the firms in each year in thousands of euros. Finally, we used the logarithm of the Earnings Before Interest, Taxes, Depreciation and Amortization (EBITDA) of the firm for each year in thousands of euros. These variables are alternatively measured of profitability and we aimed to see if results varied

between the 3 different regressions estimated. Regarding the profitability measures, the hypothesis under analysis is:

[H3] The higher the profitability of the firm (measured by the GVA, Assets or EBITDA), the higher its probability of being certified with ISO 14001.

This hypothesis is justified by the fact that certification usually requires a considerable amount of resources to be implemented.

The Return on Equity (ROE) is also used and represents the ratio between net income (it should be noted that operating income is sometimes used) and the company's total equity in a given period, presented as a percentage. In this case, the research hypothesis is:

[H4] Firms with higher ROE have a higher probability of being certified.

As before, ROE is a measure of the firm's financial stability and strength of a firm. Hence, firms that are financially stable have more available resources to invest in certification.

To control the size of firms we included the SME classification of Decree-Law No. 372/2007, which classifies the firms into micro, small, medium or large. For that we used dummies variables, where large firms are the group of comparison. Regarding the size of the firm, the research hypothesis is:

[H5] Larger firms have a higher probability of being certified.

This hypothesis relates to the aspects explained before. Usually, larger firms have more financial stability and available resources than smaller ones. Hence, they can afford to invest in the certification process more easily than smaller firms.

The sector of activity was also used as an independent variable – dummies variables for the 3 sectors (primary, secondary and tertiary). Regarding this topic the research hypothesis is:

[H6] The sector of activity of a firm influences its probability of adopting ISO 14001 certification.

3.4. Statistical description of data

Proceeding with the statistical analysis of the data, Table 1 shows the main statistical measures of the variables used in the models. The sample mean for Asset yield is approximately 3% and the median is 2.75%, indicating a positive skewed distribution. As for the value of Total Assets, the disparity between the median value in relation to the average value shows that the sample reflects the Portuguese reality with a business fabric mostly made up of small and medium-sized companies (more than 76% of the firms in the sample are SMEs).

The average of the ISO 14001 variable, as it is a binary variable, represents the proportion of observations with ISO 14001 certification in the total of observations in the sample, being approximately 33%. This happens because the year 2020 was used as a reference for the selection of companies with ISO 14001 certification and therefore many companies were not certified since the beginning of the period under analysis, specifically, in 2010 only 15% of the 1917 companies have ISO 14001 certification, rising to 50% in 2020.

Table 1. Descriptive statistics.

Variables	Whole sample				
	Mean	S.D.	Min.	Max.	Observations
ISSO	0.3294	0.47	0	1	21,087
Stock	0.0042	0.0645	0	1	21,087
Exporter	0.6667	0.4714	0	1	21,087
ROE (in %)	10.3612	28.6137	-302.35	299.91	21,087
GVA (in logarithm)	3.3364	0.7354	0	6.6012	20,527
Asset (in logarithm)	3.8830	0.8159	0	7.2054	21,086
EBITDA (in logarithm)	2.8553	0.8524	0	6.0384	19,431
Sector I	0.0083	0.0910	0	1	21,087
Sector II	0.6557	0.4751	0	1	21,087
Sector III	0.3359	0.4723	0	1	21,087
Micro	0.0878	0.2830	0	1	21,087
Small	0.2914	0.4544	0	1	21,087
Medium	0.4120	0.4922	0	1	21,087
Large	0.2088	0.4065	0	1	21,087

Source: Own elaboration from STATA

To verify the multicollinearity of the variables, Table 2 presents the correlation coefficient between the variables and the respective p-value.

Through the analysis of Table 2 it is possible to verify that certain variables are weakly correlated, except in the case of variables Asset, GVA, EBITDA and between Sector II and Sector III.

In the case of variables Asset, GVA and EBITDA, in order to analyze whether these variables affected the adoption of ISO 14001 certification we estimate 3 Binary Logit Regressions, for each one of the variables in question.

Regarding sectors and size of the firms, as dummies variables, we exclude from the regressions the variables Sector III and Large size firms, which will serve as basis for comparison.

Table 2. Correlation matrix.

Variable	Stock	Exporter	ROE	GVA (in log.)	Asset (in log.)	Ebitda (in log.)	Sector I	Sector II	Sector III	Micro	Small	Medium
Stock	1											
Exporter	-0.023***	1										
ROE	-0.006	0.013*	1									
GVA (in log.)	0.047***	0.180***	0.090***	1								
Asset (in log.)	0.143***	0.173***	-0.019***	0.858***	1							
EBITDA (in log.)	0.122***	0.179***	0.177***	0.873***	0.901***	1						
Sector I	-0.006	-0.008	-0.010	-0.028***	0.015**	0.005	1					
Sector II	-0.072***	0.249***	-0.027***	-0.096***	-0.142***	0.139***	-0.127***	1				
Sector III	0.074***	-0.249***	0.029***	-0.091***	-0.153***	-0.142***	-0.065***	-0.982***	1			
Micro	-0.015**	-0.196***	0.023	-0.545***	-0.470***	-0.428***	0.034***	-0.175***	0.169***	1		
Small	-0.014**	-0.059***	-0.0233***	-0.431***	-0.376***	-0.389***	0.040***	-0.006	-0.002	-0.199***	1	
Medium	-0.038***	0.114***	0.0114*	0.164***	0.146***	0.133***	-0.041***	0.151***	-0.144***	-0.260***	-0.537***	1
Large	0.072***	0.065***	0.0382**	0.641***	0.571***	0.552***	-0.019***	-0.055***	0.059***	-0.159***	-0.329***	-0.430***

Source: Own elaboration, from STATA. In log.: in logarithm. The symbols ***, **, and * represent statistical significance at the level of 1%, 5% and 10%, respectively.

4. Results

Table 3 list the estimates from the Binary Random-Effects Logit Models with Panel Data. The estimates in Model 1 (M1) are from regression using GVA, while the estimates of Model 2 (M2) consider the variable Asset, and Model 3 (M3) consider the variable EBITDA, all in logarithm.

Table 3. Results of the Binary Random-Effects Logit Regressions.

Variables	Model 1		Model 2		Model 3	
	Estimate	t-values	Estimate	t-values	Estimate	t-values
Stock	4.027**	2.43	-0.739	-0.44	2.997*	1.88
Exporter	-0.128	-0.54	-0.200	-0.77	-0.052	-0.22
ROE	-0.000	-0.21	0.000	0.38	-0.000	-1.12
GVA	2.453***	18.11	-	-	-	-
Asset	-	-	3.476***	21.58	-	-
EBITDA	-	-	-	-	1.247***	13.58
Sector I	0.003	0.00	-1.471	-1.18	-0.361	-0.32
Sector II	-0.266	-1.10	-0.774***	-2.92	-0.352	-1.51
Micro	-1.582***	-4.74	-1.485***	-4.76	-3.324***	-10.62
Small	-0.760***	-3.42	-0.509**	-2.39	-1.808***	-8.76
Medium	0.037	0.23	0.125	0.77	-0.572***	-3.56
Constant	-10.420***	-17.26	-15.780***	-21.85	-4.959***	-12.82
σ_u	3.2119 (0.0623)		5.3146 (0.1674)		4.7538 (0.1487)	
ρ	0.8830 (0.0064)		0.8957 (0.0059)		0.8729 (0.0069)	
Log-likelihood	-6714.7868		-6737.519		-6471.5427	
Observations	20,527		21,086		19,431	

The symbols ***, **, and * represent statistical significance at the level of 1%, 5% and 10%, respectively.

It is possible to observe a certain variation in results depending on the model specification used. This confirms the interest of testing alternative profitability measures, as we do in our study, since not all models depict the same outcomes. Still, we attempt to summarize the results focusing on the cases where variables are statistically significant. Firstly, all alternative **profitability** indicators (GVA, Assets, and EBITDA) increase the probability of certification. This result confirms **[H3]** which is in line with Heras-Saizarbitoria et al. (2011). It indicates that highly profitable firms not only have more resources to invest in certification, but also may have higher concerns with their image. Additionally, ROE is not a statistically significant variable. Hence, **[H4]** is rejected.

According to M1 and M3, a company listed on the **Stock Exchange** has a higher probability of certification. This result confirms **[H1]** and is in line with the literature (Sarumpaet, 2005). It can be

explained by the fact that certification increases the reputation of the firm, which is an important factor in the stock market. However, this variable is not statistically significant on M2.

According to M2, firms from the secondary **sector** (Sector II) are less likely to be certified. Hence, [H6] is partially confirmed indicating that the sector of activity of the firm influences its probability of being certified. This can seem counterintuitive since these firms are more likely to be the ones with higher pollution levels. However, it can also be the case that, for that same reason, they are less willing to go through the certification process because they fear high economic losses due to stronger environmental concerns. Regarding the **size** of the company, according to all specifications, smaller companies or the ones with the lower probability of adopting ISO 14001 certification. This confirms our [H5] and is in line with the literature, for example, Nakamura (2001), Sartor et al. (2019b) and Hang et al. (2019).

One very surprising result is the fact that a firm **export** does not affect its probability to be certified in any of the specifications, since this variable is not statistically significant, hence, it is not possible to confirm [H2]. This result is contrary to what has been found in most literature (e.g., Nakamura, 2001; Christmann and Taylor, 2001; Zeng et al, 2005; Cushing et al., 2005; Wu et al., 2007; Fikru, 2014) and is likely related to the specificities of our sample.

5. Conclusions

The goal of this study was to contribute to the literature on the determinants of environmental certification. In particular, we aimed to verify the influence of some factors in the probability of a company having ISO 14001 certification. We tested three different models using alternative profitability measures (GVA, Assets, and EBITDA).

The results obtained confirmed that firm-specific factors have a statistically significant influence on the probability of a company to adopt the ISO 14001 certification.

In the three estimations performed, the different measures of profitability considered demonstrated a statistically significant positive impact in the probability on a company to adopt the ISO 14001 certification, which is in line with Heras-Saizarbitoria et al. (2011).

Our results also showed that large firms are more likely to adopt ISO 14001 certification than smaller ones, which is in line with Hang et al. (2019). This can be justified by a greater need of large firms, to improve their reputation or to have access to some markets where this kind of certification is na obligation. Furthermore, larger firms likely have more wasteful procedures (due to lower control) and hence may benefit more from cost savings due to environmental improvements. Furthermore, as Miroshnychenko et al. (2017) indicate, the adoption of ISO 14001 may require large investments and it is an expensive and time-consuming process (Ong et al. 2016), something that can limit the adoption of ISO 14001 by micro, small and medium firms.

Another relevant factor that increased the probability of ISO 14001 adoption is the participation of the firm in the stock market. This is likely due to image improvements. On the other hand, our study did not find evidence that exporting firms are more likely to adopt ISO 14001 when compared to firms which only act in the internal market.

One possible implication of our results is the need to increase certification in smaller firms, with lower profitability, and that do not participate in the stock market. For this outcome, two components are important. Additional consumer pressure, as stated by Camilleri et al. (2022), and governmental support to increase firms ability to spend resources (money and time). These two aspects have also

been pointed out by DAdamo (2022). If certification was made mandatory, without financial aid from the government, many firms would probably be out of the market.

There are some limitations to our work. First, although the number of firms considered is already relevant, it would be interesting to increase the sample size and the number of years considered, seeking to include more firms, especially, more firms that are listed on the stock exchange and that are in the primary sector, since the representativeness of firms with such characteristics is low in the sample analyzed. Furthermore, it would be interesting to make an international comparison of the adoption of ISO 14001 by firms with the same characteristics. Such limitations can be seen as opportunities for future research.

As mentioned above, there may be companies that, despite not being legally certified, have implemented the requirements of the ISO 14001 standard in their environmental management system. It would be interesting in the future to carry out comparative studies between these companies and companies that actually adopted ISO 14001 certification.

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Conflict of interest

All authors declare no conflicts of interest in this paper.

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