THE IMPACT OF ISO 14001 ON FIRM ENVIRONMENTAL AND ECONOMIC PERFORMANCE: THE MODERATING ROLE OF SIZE AND ENVIRONMENTAL AWARENESS

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Abstract

This paper analyzes the impact of adopting the ISO 14001 standard on firm environmental and economic performance. In particular, it is argued that the degree of environmental awareness of the society (EAS) and firm size are two factors moderating the effect of ISO 14001 on firm performance. A number of hypotheses are formulated and empirically tested on an international sample of 583 listed companies in 46 countries over the period 2009-2018. The findings show that (i) ISO 14001 adoption contributes to reducing firm carbon emission intensity and increasing firm profitability; (ii) the impact of ISO14001 on profitability is greater for companies from countries with high EAS and for larger firms; and (iii) the impact of ISO 14001 on carbon intensity is greater for headquartered in countries with low EAS. Managerial and policy implications resulting from the widespread adoption of certifiable environmental standards are also discussed.

Keywords

ISO 14001; Environmental Management Systems (EMS); CO_2 Emissions; Profitability.

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1. INTRODUCTION

Since its release by the International Organization for Standardization in 1996, the ISO 14000 series have become widespread among firms around the world.[1] Despite its remarkable global expansion, the potential benefits and drawbacks of ISO 14001 adoption are still under debate among managers and scholars (e.g. Boiral et al., 2018; Heras-Saizarbitoria and Boiral, 2013). Furthermore, previous empirical research provides inconclusive evidence on the actual impact of this certifiable standard on firm performance: while a number of studies suggest that ISO 14001 adoption has a significant impact on improving management practices and firm performance (e.g. Iwata et al., 2010; Nishitani et al., 2012; Russo, 2009; Testa et al., 2014), others question the standard's effectiveness (Boiral, 2007; Boiral and Henri, 2012; King et al., 2005).

Heras-Saizarbitoria and Boiral (2013) and Boiral et al. (2018) provide updated and comprehensive reviews of the empirical literature on ISO 14001. The authors summarize the main findings of previous studies and identify analytical limitations and research gaps. They claim that most empirical analyses (i) focus on a single country; (ii) use cross-sectional data; (iii) analyze information gathered through questionnaires, i.e., based on managers' perceptions; (iv) ignore contextual factors such as the culture and values of the region where firms operate; and (v) overlook important environmental issues such as greenhouse gas emissions when measuring the environmental impact of firms. Therefore, a better understanding of the real outcomes of ISO 14001 adoption requires further empirical research based on longitudinal and broader international samples grounded on secondary data sources to explore factors that may act as moderators of the impact of ISO 14001 on environmental and economic indicators.

[1] In 2018, approximately 447,547 sites in 181 different countries were awarded ISO 14001 certification (ISO Survey, 2018).

The research in this paper is motivated by the above considerations. Specifically, the paper analyzes the impact of the adoption of ISO 14001 on the environmental and economic performance of an international sample comprising 583 firms from 46 countries operating in 16 different sectors over the period 2009-2018. We measure firm environmental performance by the rate of carbon intensity, defined as tons of CO_2 emitted by the company per unit of output, while economic performance is evaluated by return on assets (ROA). Furthermore, the adoption of ISO 14001 is measured with a variable that captures the degree of implementation across a firm's sites. Additionally, we formulate and empirically test a number of hypotheses about the moderating role of the environmental awareness of the society and firm size in the environmental and economic impact of ISO 14001 adoption. Finally, we note that all variables used in the analysis come from the Thomson Reuters Datastream and Eikon databases. Therefore, our variables do not depend upon the subjectivity of any respondent. Moreover, the longitudinal, multi-sectorial and international character of our sample allows us to account for time-, sector- and country-specific effects.

The remainder of the paper is structured as follows. Section 2 presents a theoretical discussion and the development of our hypotheses. Section 3 presents the data, variables and empirical modeling strategy. Section 4 presents the results, while Section 5 discusses the main conclusions and implications of our findings.

2. THEORETICAL FRAMEWORK AND HYPOTHESES

Our theoretical framework is articulated around six hypotheses. The first two explore the consequences of ISO 14001 adoption for firm environmental and economic performance, measured as the carbon intensity (rate of CO_2 emissions) and the profitability of the firm, respectively. The next two hypotheses focus on how firm size moderates the impact of ISO 14001 adoption on both CO_2 emissions and profitability. Finally, the last two hypotheses examine how the environmental awareness of the country determines the relationships of ISO

14001 adoption with CO_2 emissions and profitability. Figure 1 offers a graphical representation of the theoretical model.

Insert Figure 1 about here

2.1. The impact of ISO 14001 on environmental performance and profitability

ISO 14001 is an international certifiable standard providing a systematic framework that helps firms control their environmental impact. According to Deming's (1986) continuous improvement mode, such a framework requires establishing an environmental policy with specific objectives, creating a monitoring program to control and improve the effectiveness of the environmental policy, and undertaking corrective actions when necessary (Boiral and Henri, 2012; Delmas and Montes-Sancho, 2011). The practical implementation of this framework usually compels firm to acquire the best available environmental technologies and to develop training programs aimed at involving all staff in environmental management (Prakash and Potoski, 2014).

ISO 14001 is a process-based standard (Boiral and Henri, 2012; Heras-Saizarbitoria and Boiral, 2013). It does not establish specific outcomes but instead defines a set of practices that guide firms in environmental management. These practices are expected to improve the rigor with which firms monitor and seek to reduce their impact on the environment (González-Benito and González-Benito, 2008; Turk, 2009; Zeng et al., 2005). For instance, the documentation of environmental procedures required by ISO 14001 enables firm to increase control over the consequences of their activities for the ecosystem and adopt eventual corrective actions (López-Fernández and Serrano-Bedia, 2007; Morrow and Rondinelli, 2002). Moreover, the practices defined by ISO 14001 are likely to lead to higher commitment of managers and employees to the environmental management of the firm (Boiral, 2007; Nguyen and Hens 2015; Schylander and Martinuzzi, 2007).

Because the integration of the systematic framework defined by ISO 14001 is usually associated with the adoption of better environmental technologies, more rigorous organizational procedures to protect natural resources, and stronger environmental awareness among managers and employees, ISO 14001 adoption is expected to ultimately result in improved environmental performance (Curkovic and Sroufe, 2011; Garrido et al., 2020; Erauskin-Tolosa et al., 2020; Molina-Azorín et al, 2009; Testa et al., 2014). Accordingly, our first hypothesis proposes the following:

H1: *ISO 14001 adoption contributes to increased firm environmental efficiency.*

Although ISO 14001 was primarily launched to guide firms in the control of their environmental impact, it may have further-reaching operational and economic consequences[2]. First, from an operational perspective, ISO 14001 is considered a management tool whose adoption requires adapting and modifying many of the firm's technical processes (Heras-Saizarbitoria and Boiral, 2013; Orcos and Palomas, 2020). In particular, firms implementing ISO 14001 must redesign their processes with the goals of optimizing the use of materials, eliminating redundant production and packaging procedures, and reducing energy and water consumption (Lo, Yeung and Cheng, 2012). This redesign of technical processes often leads firms to operate with higher efficiency (Darnall and Edwards, 2006; De Jong et al., 2014; Schoenherr, 2012). For instance, empirical evidence has shown that ISO 14000 adoption results in enhanced workforce productivity (Ozusaglam et al., 2018; Treacy et al., 2019), lower required time for manufacturing (Melnyk et al., 2003), more efficient investments in R&D due

[2] Likewise, previous studies show that the implementation of other certified management standards, fundamentally ISO 9001, significantly impacts firm operations (Heras-Saizarbitoria and Boiral, 2013) while enhancing firm legitimacy (e.g. Boiral, 2003; Heras-Saizarbitoria and Boiral, 2019).

to better management of resources (He and Shen, 2019), lower operating costs (Lo et al., 2012; Treacy et al., 2019), and better use of materials and energy (Waxin et al., 2020).

Second, from an economic perspective, it is often argued that ISO 14001 adoption confers different advantages to firms via enhanced legitimacy (Bansal and Hunter, 2003; Delmas and Toffel, 2008; Graffin and Ward, 2010). Firms are perceived as legitimate actors when their activities are seen as desirable or appropriate within a socially constructed system of beliefs, values and norms (Suchman, 1995). Being identified as a legitimate entity is in the interest of any firm, as such recognition brings advantages like easier access to resources, institutional support and long-term viability (DiMaggio and Powell, 1983; Oliver, 1991; Meyer and Rowan, 1977). One of the ways in which firms may seek to be perceived as legitimate actors and receive the corresponding benefits of social approval is by developing proactive environmental behaviors (Bansal and Roth, 2000; Berrone, et al., 2017; Darnall et al., 2010). Firms characterized by their environmentalism may take advantage of a higher volume of sales (Chen and Ho, 2019; Radhouane et al., 2018) and enhanced customer satisfaction and loyalty (Danso et al., 2019; Tang et al., 2012).

By allowing firms to signal their environmental proactivity in a credible way, ISO 14001 certification is often employed as a means to satisfy social expectations and, in turn, to obtain the benefits of legitimacy (Bansal and Bogner, 2002; King, et al., 2005; Montiel et al., 2012). The capacity of ISO 14001 to provide legitimacy has been proved to some extent by studies showing that it improves the relationships of adopting firms with stakeholders such as customers (Chiarini, 2017), authorities (He et al., 2018), shareholders (Xu et al., 2016), potential investors (Jacobs et al., 2010) and employees (Rondinelly and Vastag, 2000). Additionally, the fact that ISO 14001 confers social approval by improving the image and reputation of firms is a recurring argument in the previous literature (Boiral 2007; Heras-Saizarbitoria et al., 2011; Jiang and Bansal 2003; Psomas et al., 2011).

In summary, it is expected that ISO 14001 adoption allows firms to both (i) operate with higher efficiency, which reduces operation costs, and (ii) attain legitimacy, which may result in advantages such as a higher volume of sales and a wider acceptance of firms' products and services. Accordingly, our second hypothesis posits the following:

H2: *ISO 14001 adoption contributes to increased firm profitability.*

2.2. Firm size as a contingent factor of the impact of ISO 14001

Effective implementation of ISO 14001 is required to obtain a significant effect of its adoption. It has been argued that the internalization of the procedures defined by ISO 14001 largely shapes its consequences[3] (Castka and Prajogo, 2013; Iatridis and Kesidou, 2018; Testa et al., 2018). When adopting ISO 14001, firms may implement it either symbolically or substantively (Aravind and Christmann, 2011; González et al, 2020; Lannelongue et al., 2014). Under symbolic adoption, ISO 14001 procedures are superficially incorporated. In spite of the control of certification bodies, some firms are able to obtain ISO 14001 certification without a total commitment to this environmental standard (Boiral, 2007; Christmann and Taylor, 2006). This approach to ISO 14001 adoption, which is known as decoupling, allows firms to be perceived as legitimate actors without experiencing the disruption of introducing new practices (Meyer and Rowan, 1977). By contrast, substantive adoption is a real and full integration of the ISO 14001 framework into the firm's daily activities. Whereas symbolic adoption does not necessarily confer the environmental and operational benefits attributed to ISO 14001, substantive adoption enables firms to obtain all the intended advantages of this EMS (Aravind and Christmann, 2011; Yin and Schmeidler, 2009).

We contend that large firms are more likely to substantively adopt ISO 14001 and, in turn, attain the environmental and operational benefits associated with it for two main reasons.

[3] The role of internationalization has been also explored by considering other certified management standards, mostly quality standards (see, for instance, Briscoe, et al., 2005; Tarí et al., 2013, 2020). The conclusions reached when analyzing quality standards are similar to those obtained for ISO 14001.

First, the implementation of the operational framework of ISO 14001 involves a significant investment of cost and time (Bansal and Bogner, 2002; Boiral, 2011; Darnall, 2006). Consequently, firms need a sufficient level of resources to effectively implement this EMS. As many authors have noted, the size of the firm largely determines the level of resources available to implement ISO 14001 and subsequent certification (Melnyk et al., 2003; Nishitani, 2009; Szymanski and Tiwari, 2004). Whereas small firms may fail to fully incorporate certain environmental practices due to their lack of resources (King and Lenox, 2001), large firms have the required resources to properly undertake the operative modifications required by ISO 14001. For instance, González et al. (2008) show that larger firms are more efficient in implementing material use-reduction practices than smaller firms.

Second, in general, the larger the size of the firm, the higher its visibility. As large firms are more visible, they usually attract more attention from the media and other stakeholders (McGuire and Dilts, 2008; Paulraj and De Jong, 2011; Rindova et al., 2006). The higher public scrutiny to which large firms are subject increases the likelihood that social audiences will detect greenwashing behaviors such as symbolic adoption of ISO 14001 and, in turn, initiate disciplinary actions. When firms are perceived as opportunistic and their decoupling behaviors are detected, they are morally evaluated (King and Lenox, 2000; Lange and Washburn, 2012). This evaluation may result in a common perception that the firm is unreliable and untruthful (Berrone et al., 2017), negatively affecting its image and its relations with stakeholders. The high risk of social punishment that large firms experience because of their high visibility reduces their incentives to symbolically implement ISO 14001 while increasing the perceived appeal of substantively integrating this EMS.

Basing on the above discussion, we argue that small firms are more likely to symbolically adopt ISO 14001, whereas large firms are more willing to undertake a substantive implementation of this environmental standard. As substantive implementation is associated with better control of the firm's environmental impact and higher operational advantages (Aravind and Christmann, 2011; Yin and Schmeidler, 2009), we expect that the larger the size of the firm, the greater the increase in profitability and environmental efficiency arising from ISO 14001 adoption. Accordingly, our next hypotheses propose the following:

H3: *The difference in environmental efficiency between ISO 14001 adopters and non-adopters is greater among large firms than among small firms.*

H4: *The difference in profitability between ISO 14001 adopters and non-adopters is greater among large firms than among small firms.*

2.3 Environmental awareness of society as a contingent factor of the impact of ISO 14001

The consequences of ISO 14001 may vary depending on the features of the country (Garrido et al., 2020; Prakash and Potoski, 2014). We argue that the degree of environmental awareness of the society (hereafter EAS) is a major country-level factor determining the relative impact of ISO 14001 adoption for two reasons. First, the level of EAS is associated with the development of specific social expectations, regulations and policies that shape the competitive arena in environmental (and non-environmental) matters. Second, the values of the societal context greatly influence individual behaviors and choices (e.g. Peng et al., 2009; Schneider and De Meyer, 1991). Thus, managers from countries with different degrees of EAS may show differences in their commitment to addressing environmental concerns.

Under high EAS, the public demand for environmental safeguards and remedies to environmental problems is more intense. In general, countries with high EAS are characterized by more comprehensive legislation and more ambitious regulatory policies aimed at protecting natural resources and thus show better overall environmental indicators. Consequently, firms embedded in such societies usually obtain higher rewards from environmental behaviors such as ISO 14001 adoption, as their environmentalism is consistent with societal values and expectations (DiMaggio and Powell, 1983; Meyer and Rowan, 1977). For instance, compared with weak EAS countries, in strong EAS countries customers are more willing to pay higher prices for sustainable products, investors require lower returns from environmentally responsible firms, and governments reward and subsidize firms developing environmental initiatives.

Furthermore, the price of polluting resources (e.g. fossil fuels) is typically higher in countries with high EAS than in countries with low EAS. As a consequence, the operating costs savings resulting from effective implementation of ISO 14001 procedures should be comparatively higher in countries with high EAS. Similarly, penalties for polluting are usually higher in countries with high EAS, and the legal costs of pollution and ecological incidents may be substantial for firms (Flammer, 2013). ISO 14001 adoption helps firms comply with environmental regulations (McGuire, 2014; Potoski and Prakash, 2005) and therefore avoid these higher fines and sanctions in countries with high EAS. In summary, we argue that firms can attain greater profit from adopting ISO 14001 under high EAS compared with low EAS, leading us to formulate the following hypothesis:

H5: *The difference in profitability between ISO 14001 adopters and non-adopters is greater among firms from high EAS countries.*

With respect to environmental impact, two opposing directions of the moderating effect of EAS on the relative impact of ISO 14001 adoption are possible. On the one hand, following the discussion above, firms under low EAS are likely to operate under weaker pressure to address environmental concerns and thus exert lower managerial effort to reduce the environmental impact of their activities. Thus, the difference in firm-level environmental performance between ISO 14001 adopters and non-adopters should be greater under low EAS than in an environmentally demanding context (high EAS). To some extent, ISO 14001 can fill gaps left by a lack of appropriate environmental institutions and regulations.

On the other hand, firms adopting ISO 14001 in high EAS countries could have a greater tendency to recruit managers with stronger environmental consciousness and capabilities than non-adopting firms in order to ensure effective implementation of the standard. Such managers would be committed to substantively integrating the procedures of this certifiable standard, thus magnifying its impact (Aravind and Christmann 2011; Castka and Prajogo 2013; Garrido et al., 2020; Yin and Schmeidler, 2009). If so, the difference in environmental outcomes between ISO 14001 adopters and non-adopters would be greater under high EAS than low EAS.

Based on the opposing arguments discussed above, we propose two alternative hypotheses:

H6a: *The difference in environmental efficiency between ISO 14001 adopters and non-adopters is greater among firms from low EAS countries.*

H6b: *The difference in environmental efficiency between ISO 14001 adopters and non-adopters is greater among firms from high EAS countries.*

3. EMPIRICAL ANALYSIS

3.1. Data sample

The main source of data used in the empirical analysis is the Thomson Reuters Datastream and Eikon databases, which provide firm-level information on the dependent and independent variables discussed below. Based on the available data, our sample comprises 583 public listed firms from 2009 to 2018, resulting in a total of 6,733 firm-year observations. Figure 2 and Tables 1 and 2 illustrate the richness of our database, which includes observations from a wide variety of ISO 14001 certified and non-certified firms from a broad spectrum of sectors and countries (16 industries, 46 countries).

Insert Figure 2, Table 1 and Table 2 about here

3.2. Variables

Our research explores the impact of ISO 14001 adoption on two dependent variables, namely, economic performance and environmental performance. Economic performance is measured by return on assets (ROA), which is defined as the ratio of net profit to total assets. *ROA* reflects the efficiency of a firm's use of its assets to generate profits (Minutolo et al., 2019). Environmental performance is proxied by the rate of CO_2 emissions (RCO_2), defined as tons of carbon dioxide emitted by the firm divided by total revenue. RCO_2 is therefore an indicator of a firm's carbon intensity, which is equivalent to the standard emissions intensity measure used at the macroeconomic level (i.e. CO_2/GDP).

Our main independent variable is *ISO*, which is measured as the percentage of facilities of a firm that have ISO 14001 certification; i.e. the variable *ISO* ranges from 0 for firms without any certified facility to 100 for firms in which all facilities are certified with the environmental standard. To our knowledge, this measure is a novelty in the literature, as most studies identify the adoption of ISO 14001 with dichotomous variables only (Aragon-Correa et al., 2020).

Our theoretical framework proposes that the effect of ISO 14001 adoption varies according to firm size and EAS. Whereas we measure the first variable as the natural logarithm of the number of employees (*SIZE*), we proxy the second one through the Environmental Performance Index (*EPI*). The EPI was developed by Yale University (Yale Center for Environmental Law and Policy) and Columbia University (Center for International Earth Science Information Network) in collaboration with the World Economic Forum. The EPI quantifies and numerically indicates the environmental performance of a state's policies. It is based on 24 environmental indicators clustered into two areas: (1) environmental health and

(2) ecosystem vitality. The EPI has been released since 2006 and has become one of the best-known indexes for tracking the environmental performance of countries (Oţoiu and Grădinaru, 2018). Wendling et al. (2018) provide more details on the index and its construction.[4] The value of *EPI* ranges from 0 to 100, with higher values indicating better environmental performance of the country. We assume that higher values of *EPI* are associated with higher levels of EAS.

Many firms in the sample are multinational corporations. For these firms, *EPI* corresponds to the EPI value for the firm's country of origin, consistent with the fact that the top management teams of multinational corporations are typically dominated by country-of-origin nationals (Ferner, 1997). Accordingly, several studies have shown persistent country-of-origin effects in multinational corporations (Harzing and Sorge, 2003; McGahan and Victer, 2010), indicating that the management of international firms is largely determined by the features of the country of origin. Consequently, it seems reasonable to expect that strategic choices such as general adoption of ISO 14001 across a firm's sites are made by managers who are heavily influenced by the societal context of the country of origin.

Our model also controls for several firm- and country-specific factors. Thus, we introduce the dummy variable (*QMS*) to indicate whether the firm has a certified quality management system. We introduce this variable to capture potential learning effects from the implementation of a quality management system (Albuquerque et al., 2007; Darnall et al., 2008; Vastag, 2004). Likewise, we account for the capital intensity of the firm (*KL*), measured as the ratio of assets to the total number of employees (Lee and Min, 2015). In principle, we expect that more capital-intensive production processes require a higher quantity of energy consumption and thus higher carbon emission levels. Furthermore, we control for the country's level of economic development by means of the logarithm of the gross domestic product per

[4] Data on EPI can be freely downloaded at https://epi.envirocenter.yale.edu/.

capita (*GDP*) (e.g. Mertzanis et al., 2019). Finally, each model specification also includes industry, country and year dummies.

Descriptive statistics and correlations of the study variables are shown in Table 3. The mean value of ISO 14001 adoption is 33.21%, which indicates that, on average, the firms in our sample have obtained ISO 14001 certification for approximately one third of their facilities. With respect to the average size of firms included in the sample, the mean number of employees is 9,798 (the natural logarithm is 9.19).

To check for multicollinearity, we assess the bivariate correlations and the variance inflation factor (VIF) values. The correlation values among all variables are generally low to moderate, suggesting there is low risk of collinearity issues or redundancies. The absence of multicollinearity in our estimated models is further indicated by the maximum VIF value of 1.52, which is well below the suggested cut-off of 10 (Kutner et al., 1996).

Insert Table 3 about here

3.3. Empirical modeling

We use a two-step system generalized method of moments (GMM; Stata 14 xtabond2 command) to test our hypotheses. The GMM is treated as a dynamic panel and can solve the problem of endogeneity associated with dynamic panel data (Schultz et al., 2010; Ullah et al., 2018). A two-step GMM model provides more efficient estimates for the involved coefficients than one-step estimators and avoids the loss of too many observations typically associated with one-step GMM (Ullah et al. 2018). The following regression model is estimated:

$$y_{it} = \alpha_1 y_{it-1} + \alpha_2 y_{it-2} + \beta_1 ISO_{it} + \beta_2 EPI_{it} + \beta_3 SIZE_{it} + \beta_4 ISO_{it} EPI_{it} + \beta_5 ISO_{it} SIZE_{it} + \tau_1 KL_{it} + \tau_2 QMS_{it} + \tau_3 GDP_{it} + \gamma Industry_s + \lambda Country_j + \delta Year_t + \varepsilon_{it}$$

where y_{it-1} indicates one-year lag of the dependent variables (*ROA* and RCO_2) and y_{it-2} denotes a two-year lag of the dependent variables; $Industry_s$ is a vector of industry-specific dummy variables; $Country_j$ is a vector of country-specific dummy variables; $Year_t$ is a vector of time-specific dummy variables; $\alpha,\beta,\tau,\gamma,\delta,\lambda$ are regression coefficients, and ε_{it} is the disturbance term.

The lags are included as independent variables in our GMM model as suggested by Ullah et al. (2018). Following Canh et al. (2019), the validity of the instruments in GMM are tested with the Hansen test, which is used to determine whether the econometric model is valid and whether the instruments are robust. Furthermore, to examine the validity of a strong exogeneity assumption, we use the Arellano-Bond test AR (2) to estimate autocorrelation under the null hypothesis that the error terms of two different periods are uncorrelated.

4. RESULTS

Tables 4 and 5 report the system GMM parameter estimates along with the relevant diagnostic tests. Table 4 shows the estimations considering RCO_2 as the dependent variable, whereas Table 5 reports the estimations with *ROA* as the dependent variable. In each table, Model 1 contains the control variables and the variable *ISO*. Model 2 incorporates the interaction term between *ISO* and *firm size* to test hypotheses 3 and 4, while Model 3 introduces the interaction term between *ISO* and *EPI* to test hypotheses 5 and 6. Finally, Model 4 includes the two pairwise interaction terms to account for possible multicollinearity among the interaction terms.

Insert Tables 4 and 5 about here

First, we start with the results of the impact of ISO 14001 on firms' environmental and economic performance, which are the focus of our two main hypotheses. As shown in Table 4, the coefficient of ISO is consistently negative and highly significant across models. That is, the more widespread the adoption of ISO 14001 within a firm, the lower the firm's carbon intensity (H1). Likewise, the coefficient of *ISO* is positive and highly significant across models in Table 5, indicating a direct association between ISO 14001 implementation and a firm's economic profitability. Our results therefore provide strong evidence in favor of hypotheses H1 and H2.

In order to examine the moderating effects of firm size and EPI, we focus on the interaction terms of both variables with the *ISO* variable. To avoid potential multicollinearity problems, the variables used to create the interaction terms are mean-centered as suggested by Aiken, West and Reno (1991). Regarding the effect of firm size, the coefficient of the interaction term between *ISO* and *SIZE* is not statistically significant in Model 2 in Table 4. Thus, in our sample, firm size is not a contingent factor determining the relationship between ISO 14001 adoption and the rate of CO_2 emissions. Consequently, hypothesis 3 is not supported. By contrast, the coefficient of the interaction term between *ISO* and *SIZE* is positive and significant in Model 2 in Table 5, indicating that the relationship between ISO 14001 adoption and profitability is stronger among larger firms as hypothesized in H4.

Finally, the interaction term between *ISO* and *EPI* is positive and statistically significant in explaining both the rate of CO_2 emissions (Table 4) and *ROA* (Table 5). This clearly indicates that the environmental awareness of the country moderates the relationship between ISO 14001 adoption and the profitability and environmental performance of the firm. The positive sign in the former case is consistent with our expectations as formulated in H5, indicating that ISO 14001 adoption results in higher economics benefits for firms in societies with high environmental awareness. In the latter case, the positive sign suggests that the difference in the rate of CO_2 emissions between firms adopting ISO 14001 and non-adopters is greater in countries with low EAS than in countries with high EAS, thus providing empirical support for hypothesis H6a.

Additionally, we run the above GMM models including the lags of both the dependent (i.e. ROA and RCO_2) and independent variables (i.e. ISO) as instruments. Likewise, we use an alternative measure of environmental performance (e.g. CO_2 divided by total assets) used in some previous studies (e.g. Nishitani et al., 2012). The results (not shown here) and conclusions do not vary with these changes in the model specification.

5. VALIDITY AND ROBUSTNESS CHECKS

To ensure the validity and robustness of our results, we conduct various analyses to address common sources of endogeneity: omitted variable bias, unobserved heterogeneity, and dynamic endogeneity. First, we employ Heckman's two-step procedure, which is commonly used to control for possible selection bias (Hamilton and Nickerson, 2003; Kong et al., 2020). The Heckman two-step procedure uses two equations to address self-selection. In the first step, called the 'selection equation', the probability of adopting ISO 14001 is analyzed with a probit model because the dependent variable is a dummy variable taking a value of 1 when a firm adopts ISO 14001 and 0 otherwise. The main purpose of the first equation is to compute the correction factor, called the inverse Mills ratio (IMR). The second step is an OLS regression, named the 'outcome equation', with the correction factor IMR included as a regressor. Table 6 report the estimates for the two Heckman models (i.e. with *ROA* and RCO_2 as dependent variables). Columns (1) and (2) show the results of the first step of the Heckman procedure for the ROA and RCO_2 regressions, respectively, while columns (3) and (4) show the results of the second step. The estimated coefficients for IMR in columns (3) and (4) are not statistically significant in any case, indicating that selection bias is not a significant issue in our model.

Second, we perform the Durbin–Wu–Hausman test to check the endogeneity of the variables and determine whether the results reported under the OLS models are consistent (Schultz et al., 2010). The Durbin–Wu–Hausman test statistics are reported in Table 7. The results show that the two independent variables presented in columns (3) and (4) of Table 6 (firm size and capital intensity) are endogenously determined; therefore, the OLS estimates are unreliable and inconsistent.

Insert Tables 6 and 7 about here

A second source of endogeneity, unobservable heterogeneity, occurs when an omitted factor affects both the dependent and independent variables and is commonly remedied by fixed- and random-effects estimations. We note, however, that random- and fixed-effects panel specifications only produce consistent parameter estimates under the assumption of strict exogeneity, i.e. the absence of a correlation between the explanatory variables and the error term of the model at each and every point in time. By definition, the assumption of strict exogeneity is necessarily violated when the model includes lags of the dependent variable, as is the case here, which should be quite common given the dynamic nature of many economic phenomena.

Critical assumptions for the validity of GMM estimates are that the instruments are exogenous (Hansen test) and that second-order serial correlations of the error term (AR2) are not present. The GMM model removes endogeneity by using internal instruments in the estimation. Specifically, the past value of the variable (including the lagged values of the dependent variable as an explanatory variable in the model) is subtracted from the current value (Roodman, 2009, Ullah et al., 2018). As shown in Tables 4 and 5, the Hansen statistics are all insignificant across the GMM models, which indicates that the instrumental variables are valid. Moreover, in the Arellano-Bond (AR) test, the significant first-order AR (1) and the insignificant second-order AR (2) error terms indicate the absence of a second-order correlation.

6. DISCUSSION

This research provides evidence that ISO 14001 adoption contributes to reducing the CO_2 emissions intensity and increasing the profitability of firms. Thus, in general, the standard brings both environmental and economic benefits. Furthermore, our results reveal that the impact of ISO 14001 adoption is contingent on both firm-level and country-level specific factors. First, whereas the previous literature tends to consider firm size as a factor influencing the choice of EMS adoption (Baek, 2017; González-Benito and González-Benito, 2005; King and Lenox, 2001; Nishitani, 2009; Ozusaglam et al., 2018), our study focuses on how size determines the environmental and economic consequences of ISO 14001 implementation. Our results indicate that firm size enhances the increase in profitability attributed to ISO 14001 adoption. By contrast, the relationship between ISO 14001 adoption and the rate of CO_2 emissions does not differ significantly as a function of firm size.

The variable used to measure environmental performance in our study might arguably explain the non-significant moderator effect of firm size. Air pollution is highly visible, and external audiences are usually worried to a greater extent about this type of pollution (Dunlap's, 1994; Gallup, 2005). Thus, to satisfy social concerns, firms may prioritize limiting air pollution over reducing other, less-visible pollutants (Prakash and Potoski, 2014). This might bias the implementation of ISO 14001 by giving more relevance to processes aimed at reducing CO_2 emissions. If so, the impact of ISO 14001 on CO_2 emissions may not vary substantially with company size because companies tend to dedicate their efforts and limited resources to abating this specific type of pollution. Future research exploring whether the environmental impact of ISO 14001 adoption varies with firm size should consider other pollutants, such as the volume of waste or water pollution.

Second, with a few exceptions (e.g. Garrido et al, 2020 and Prakash and Potoski, 2014), the moderating role of country-specific features in the outcomes of ISO 14001 adoption has been underexplored. As Boiral et al. (2018) note, the lack of international studies may explain the absence of analyses addressing country-specific factors. In this respect, our research analyzes the extent to which the environmental awareness of the society influences the consequences of standard adoption. We find that the relative economic impact of adopting ISO 14001 is greater in countries with high environmental awareness than in countries where protection of the environment is a less relevant issue. This result supports our thesis that firms embedded in societies with high environmental concern may reap more benefits from the operational costs savings and improved image resulting from ISO 14001 adoption. With respect to the relative environmental impact of ISO 14001, we provide evidence that the marginal or incremental value of adopting this EMS is higher in countries with low EAS. In other words, the contribution of ISO 14001 implementation to improving the environmental management of firms is greater in countries with lower environmental concerns. This is consistent with the premise that the environmental management of firms from high EAS countries is higher at baseline (before ISO 14001 adoption), and therefore the improvement in environmental performance due to ISO implementation is smaller than in low EAS countries.

Our findings have potential policy and managerial implications. With respect to policy, our results show that ISO 14001 adoption may increase the profitability and reduce the rate of CO_2 emissions of firms, and thus it seems appropriate for governments to design policies and initiatives intended to facilitate the implementation of this EMS. Widespread diffusion of ISO 14001, particularly in those sectors that contribute most to greenhouse gas emissions (e.g. manufacturing and transport sectors), would support the global strategy of decarbonizing the economy. As the effectiveness of ISO 14001 in reducing CO_2 emissions is higher in countries where EAS is low, governments in these settings could place extra emphasis on promoting the diffusion of this environmental standard. Likewise, as the diffusion of ISO 14001 seems to be linked to enhanced firm productivity and competitiveness, the promotion of standard adoption by governments could also foster economic growth and wealth creation within the country.

Regarding managerial implications, our results show that adoption of ISO 14001 is a wise strategic choice, as its implementation allows firms to not only reduce their environmental impact but also achieve higher profitability. As both benefits are present regardless of the country of the firm, it can be said that ISO 14001 is an effective management tool in general. However, it is important to highlight that the economic benefits of ISO 14001 are highest for large firms in countries with high environmental awareness. Therefore, managers of such firms should be aware of the extra advantage they may secure from adopting ISO 14001.

The international, multi-sectorial and longitudinal character of our sample enables proper accounting for potential bias arising from country-, sector- and time-specific factors. However, the fact that our sample consists exclusively of publicly listed firms could affect the generalizability of the results. The activities of listed firms may be subject to greater public scrutiny due to their high visibility and media coverage, and the higher control that external audiences exert on publicly listed firms may increase the extent of integration of the procedures of ISO 14001. Under a high level of public scrutiny, the attractiveness of symbolically implementing the standard decreases, since the chances of detection and punishment are very high. Therefore, listed companies may be more likely to substantively integrate ISO 14001 procedures, thereby enhancing the impact of adoption on performance (Aravind and Christmann 2011; Castka and Prajogo 2013; Lannelongue et al., 2014).

Finally, we note that most previous studies treat the adoption of ISO 14001 as a binary choice (Aragón-Correa et al., 2020). This treatment has been recently challenged by several authors, who argue that there are differences in the scope of ISO 14001 adoption among firms. Specifically, they distinguish between symbolic and substantive implementation of this environmental standard (e.g. Aravind and Christmann, 2011; González et al., 2020;

Lannelongue et al., 2014). Importantly, our variable of ISO 14001 adoption, which measures the percentage of a firm's facilities awarded ISO 14001 certification, is a useful proxy of the extent to which firms commit to the standard. Future research should explore factors explaining why some firms globally adopt ISO 14001 while others prefer partial implementation at a few sites.

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Figure 1. Theoretical model.

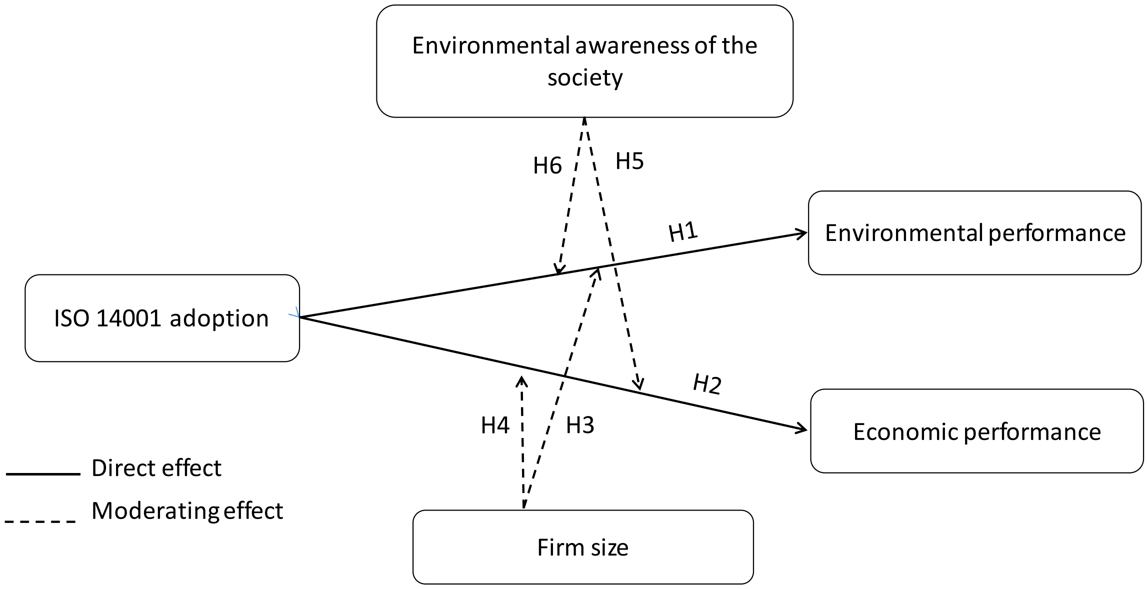

Figure 2. Countries included in the sample

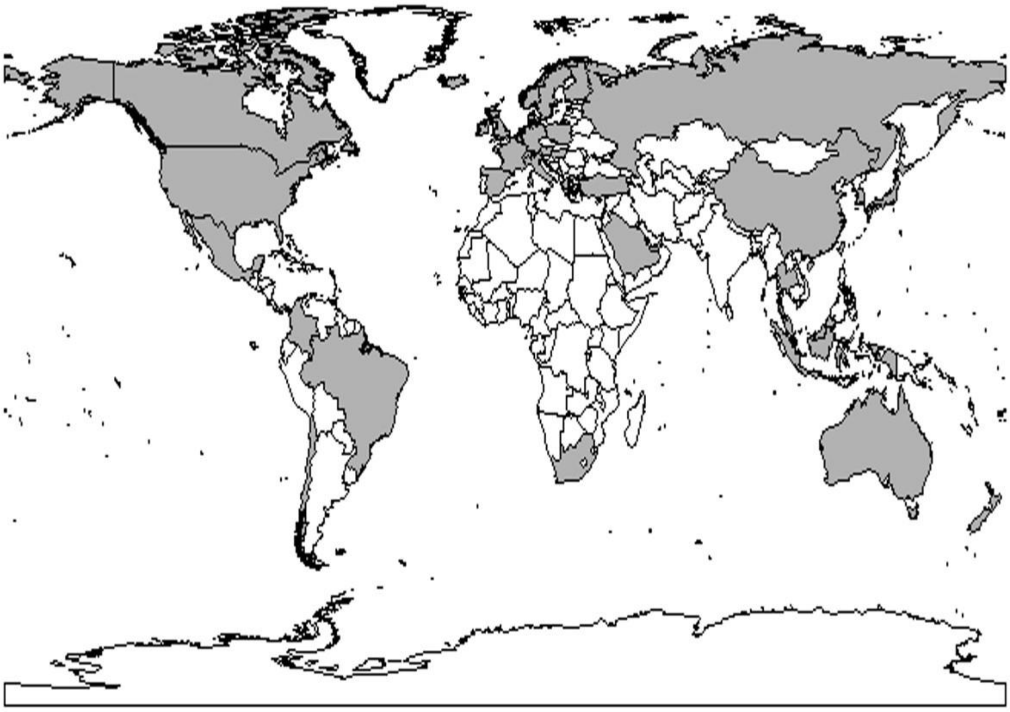

Table 1. Number of observations of certified and non-certified firms by region

Region	Certified firms	Non-certified firms	Percentage
Asia/Pacific	996	959	29.%
EMEA (Europe, the middle East and Africa)	1,451	1,503	43.9%
Latin America	115	178	4.4%
North America	258	1,273	22.7%
Total	2,820	3,913	100%

Table 2. Number of observations of certified and non-certified firms by activity sector

Sector	ISIC Rev.4 section (divisions)	Certified firms	Non-certified firms	Percentage
Accommodation & food service	A(01-03)	8	5	0.19%
Administrative and support service activities	B(05-09)	223	377	8.91%
Agriculture, forestry and fishing	C(10-33)	1,740	626	35.14%
Construction	D,E(35-39)	166	219	5.72%
Finance and insurance	F(41-43)	103	77	2.67%
Health care and social assistance	G(45,46)	31	74	1.56%
Information	G(47)	25	405	6.39%
Manufacturing	H(49-53)	131	157	4.28%
Mining and quarrying	I(55-56)	16	152	2.5%
Other services	J(58-63)	111	341	6.71%
Professional, scientific and technical services	K(64-66)	101	933	15.36%
Real estate	L(68)	31	342	5.54%
Retail trade	M(69-75)	100	140	3.56%
Transportation and storage	N(77-82)	33	41	1.1%
Utilities	Q(86-88)	0	21	0.31%
Wholesale trade	S(94-96)	1	3	0.06%
Total		2,820	3,913	100%

Table 3. Means, standard deviations and correlation coefficients.

Variables	Mean	SD	1	2	3	4	5	6	7	8
RCO_2	223.91	616.07	1							
ROA	4.99	10.37	-0.071***	1						
ISO	33.21	42.99	-0.052**	0.001	1					
EPI	72.32	11.90	0.071***	-0.027	-0.016	1				
SIZE	9.19	1.88	-0.118***	-0.008	0.244***	-0.048***	1			
QMS	0.43	0.49	-0.076***	0.003	0.552***	-0.068***	0.277***	1		
GDP	10.45	0.76	0.135***	-0.053***	-0.128***	0.566***	0.001	-0.153***	1	
KL	1.83	1.92	-0.491***	-0.103***	0.025**	-0.173***	-0.245***	-0.036**	-0.269***	1
VIF			1.39	1.52	1.39	1.35	1.46	1.40	1.37	1.35

* Significant at 5%; **Significant at 1%; *** Significant at 0.1%
SD, standard deviation; Vif, Variance Inflation Factor

Table 4. Impact of ISO 14001 on environmental performance (RCO_2)

	Model 1	Model 2	Model 3	Model 4
L1.RCO_2	0.003 (0.001)**	0.003(0.002)	0.002(0.001)	0.001(0.001)
L2.RCO_2	0.022(0.002)***	0.023(0.001)***	0.022(0.002)***	0.023(0.002)***
ISO	-0.845 (0.050)***	-0.862(0.051)***	-0.747(0.052)***	-0.780(0.054)***
EPI	-0.431(0.019)***	-0.432(0.020)***	-0.329(0.022)***	-0.337(0.054)***
SIZE	-4.812(3.730)	-3.064(3.413)	-5.185(3.667)	-5.345(3.641)
ISO* SIZE		0.011(0.031)		0.036(0.029)
ISO* EPI			0.336(0.025)***	0.326(0.026)***
GDP	0.007(0.012)	0.015(0.012)	0.016(0.012)	0.021(0.012)
KL	-0.497(0.008)***	-0.499(0.008)***	-0.486(0.007)***	-0.490(0.008)***
QMS	-0.073(0.008)***	-0.071(0.008)***	-0.065(0.007)***	-0.065(0.007)***
AR (1) p-value	0.037	0.037	0.037	0.037
AR (2) p-value	0.652	0.645	0.597	0.587
Hansen tests of overidentifying restrictions *(p-value)*	0.118	0.120	0.145	0.164

Note: * Significant at 5%; **Significant at 1%; *** Significant at 0.1%. Standard errors are reported in parentheses.
Year, industry and country effects are included in the estimations.

Table 5. Impact of ISO 14001 on economic performance (ROA)

	Model 1	Model 2	Model 3	Model 4
L1.ROA	-0.083 (0.004)***	-0.085(0.004)***	-0.084(0.004)***	-0.085(0.004)***
L2.ROA	-0.098 (0.004)***	-0.098(0.004)***	-0.098(0.004)***	-0.098(0.004)***
ISO	0.095(0.012)***	0.092(0.018)***	0.096(0.013)***	0.096(0.019)***
EPI	0.026(0.007)***	0.022(0.018)***	0.036(0.007)***	0.033(0.007)***
SIZE	0.041(0.086)	0.040(0.087)	0.038(0.087)	0.025(0.087)
ISO *SIZE		0.024(0.003)***		0.025(0.004)***
ISO *EPI			0.068(0.012)***	0.069(0.013)***
GDP	-0.061 (0.008)***	-0.056 (0.008)***	-0.065 (0.008)***	-0.062 (0.009)***
KL	-0.013(0.004)***	-0.011(0.005)**	-0.011(0.005)**	-0.008(0.005)
QMS	0.018(0.005)***	0.014(0.005)***	0.016(0.005)***	0.013(0.005)**
AR (1) p-value	0.019	0.019	0.020	0.020
AR (2) p-value	0.943	0.943	0.985	0.954
Hansen tests of overidentifying restrictions *(p-value)*	0.119	0.138	0.148	0.166

Note: * Significant at 5%; **Significant at 1%; *** Significant at 0.1%. Standard errors are reported in parentheses.
Year, industry and country effects are included in the estimations.

Table 6. Estimates of Heckman's two-step model

	(1)	(2)	(3)	(4)
	Heckman's first step (Probability of adopting ISO 14000)		Heckman's second step (OLS)	
	ROA	RCO_2	ROA	RCO_2
ISO	-	-	0.053 (0.037)	0.169 (0.069)
EPI	-0.643 (0.660)	-0.478 (0.886)	0.052 (0.306)	-0.715 (0.605)
SIZE	0.298 (0.021)***	0.316 (0.027)***	-0.128 (0.009)***	0.057 (0.018)***
GDP	0.168 (0.311)	0.513 (0.448)	0.068 (0.014)	0.059 (0.302)
KL	0.008 (0.032)	-0.081 (0.051)	-0.202 (0.014)***	0.070 (0.032)
QMS	1.143 (0.054)***	1.189 (0.070)***	-0.006 (0.031)	-0.077 (0.059)
IMR	-	-	-1.78 (2.78)	1.06 (6.49)
R-squared	0.53	0.54	0.25	0.61

Table 7. Durbin–Wu–Hausman test statistics.

	ROA		RCO2	
	F-Statistic	*p-value*	*F- Statistic*	*p-value*
ISO	0.14	0.70	0.11	0.73
EPI	0.60	0.43	0.27	0.60
SIZE	14.57	0.001	10.16	0.001
GDP	0.01	0.90	0.01	0.93
Capital intensity	104.62	0.001	109.55	0.001
QMS	0.05	0.82	0.01	0.95