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Are certified firms more prone to eco-product innovation? The moderating role of slack resources

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ABSTRACT

Sustainability is becoming essential for virtually every organization willing to thrive in a globalized world. Nonetheless, the available resources to address the challenges required to switch towards sustainability-oriented firms are scarce and yet necessary to deploy. Thus, this study focuses on the adoption of ISO 9000, ISO 14000 and OHSAS 18001 families of standards as managerial practices that can help firms in promoting eco-product innovation, considering slack resources as a moderator of this relationship. Relying on a sample composed of 2834 firms studied between years 2007 and 2020 and obtained from the Refinitiv® Eikon database, results suggest that firms holding these certifications are more prone to eco-product innovation. More specifically, ISO 14000 acts as the main driver, although its benefits are boosted when implemented in combination with ISO 9000 and/or OHSAS 18001. In fact, firms adopting multiple certifications increasingly use their slack resources to leverage eco-product innovation when firms hold at least intermediate levels of slack. All in all, this is one of the first studies, to the best of the authors' knowledge, analyzing simultaneously the different combinations of these certifications as potential drivers of eco-product innovation, as well as the moderating role of slack resources.

1. Introduction

Ever since economies around the world operate under the scheme of globalization, sustainability has increasingly caught the attention of governments, firms, customers and the society in general (Sun et al., 2022). Although sustainability is not new to firms, the major challenge lays on how to implement proper business practices that deal with its requirements (Baumgartner and Ebner, 2010).

One of the most widely implemented practices are management systems (MSs), where ISO 9000 (quality) and ISO 14000 (environmental) families of standards occupy the first places in diffusion worldwide (ISO, 2021). Both have a wide variety of potential benefits such as increased employees' motivation, better internal management and innovation (Heras-Saizarbitoria and Boiral, 2013). In this line, ISO 14000's implementation is not only considered an eco-innovation by itself but also a driver of eco-process and eco-product innovation (EPI) (Wang et al., 2022). Similarly, OHSAS 18001 certifications, updated and gradually been replaced by the ISO 45000 standards family from 2018, fosters environmental performance as an additional benefit to endorsing occupational health and safety (Wiengarten et al., 2017a, 2017b).

Although the literature highlights the relevance of environmental MSs for EPI, not many studies examine their implementation in combination with both quality and occupational health & safety MSs (Hojnik and Ruzzier, 2016; Khan et al., 2021; Nunhes et al., 2016). Some studies suggest that the implementation of multiple MSs promotes both general (see e.g., Bernardo, 2014; Hernandez-Vivanco et al., 2016), and sustainable innovation (see e.g., Hernandez-Vivanco et al., 2018). In this regard, Nunhes et al. (2016) highlighted the gap in literature relating MSs with innovation and sustainability-oriented practices, where EPI represents a field with room for further research. In fact, although MSs have been mostly related to process and technological sustainable innovations (Hernandez-Vivanco et al., 2018; Wang et al., 2022), the relationship between MSs and EPI remains in an exploratory stage based on small samples and drawing still non-conclusive results (Hernandez-Vivanco et al., 2018; Khan et al., 2021). Thus, the following research question is examined *(RQ1) Are certified firms more prone to EPI than non-certified firms?*

Furthermore, sustainability is inevitably connected to resilience in different ways that complement each other (Marchese et al., 2018; Xu et al., 2015). One of the main traits of resilient firms is that they hold a

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cushion of resources to ensure their long-run survival (Corvello et al., 2022; Cyert and March 1963). These resources are named slack (Bourgeois, 1981) and, when managed efficiently, slack facilitates achieving firms' goals and becomes necessary to ensure resilience even in extreme contexts such as the pandemic (Corvello et al., 2022; Leuridan and Demil, 2021).

One way in which firms pursue resilience is by being more adaptive through the conversion of slack into innovation (Leuridan and Demil, 2021; Schemeil, 2013). Although investing in innovation involves some uncertainty by itself, EPI is usually perceived as even riskier (Berrone et al., 2013; Nohria and Gulati, 1996). For this reason, at least some slack is necessary to innovate (Bourgeois, 1981; Nohria and Gulati, 1996; Voss et al., 2008), but more specially to be able to engage in eco-innovation projects (Leyva-de la Hiz et al., 2019; Li, 2014; Tariq et al., 2022). In this sense, slack could be deemed as a way to reduce the inherent risk of getting involved in EPI projects (Nohria and Gulati, 1996; Voss et al., 2008), therefore potentially enhancing the benefits of MSs (Hojnik and Ruzzier, 2016). Nonetheless, slack as a moderating factor of the relationship between MSs and EPI remains scarcely studied (Khan et al., 2021). This paper addresses this gap through the following research question *(RQ2) Do slack resources moderate the relationship between MSs certifications and EPI?*

To this end, a cross-national longitudinal quantitative analysis is performed. This approach is adopted given the scarce number of studies examining these relationships beyond the exploratory stage found in the existing literature (Hernandez-Vivanco et al., 2018; Khan et al., 2021).

In this research, ISO 9000, ISO 14000 and OHSAS 18001 are analyzed together. The terms ISO 9000 and ISO 14000 are used to address these standards series rather than specifically to ISO 9001 or ISO 14001 (similar to Lo et al., 2012; Naveh and Marcus, 2007). Moreover, given the longitudinal nature of this study that includes observations before 2018, the term OHSAS 18001 is used indistinctively to refer to both OHSAS 18001 and ISO 45000 standard families.

2. Theoretical framework

2.1. The relationship between certifications and eco-product innovation

The Eco-Innovation Observatory (2010, p. 7) defines eco-innovation as the "introduction of any new or significantly improved product (good or service), process, organizational change or marketing solution that reduces the use of natural resources (including materials, energy, water and land) and decreases the release of harmful substances across the whole life cycle". According to Horbach et al. (2012, p. 119), "the positive environmental effects can be explicit goals or side effects of innovations", which can arise internally or externally through company's stakeholders, specially customers (see also Al-Shami and Rashid, 2022; Carrillo-Hermosilla et al., 2010). What is relevant about these definitions is that they necessarily involve a positive impact on the environment throughout the life cycle as well as involving stakeholders to meet this objective. For this reason, environmental MSs, such as the ISO 14000 standards family, are recognized as eco-innovations by themselves that also work as drivers of other types of eco-innovation (Hojnik and Ruzzier, 2016; Wang et al., 2022).

The ISO 14000 standards family is particularly relevant for EPI since it allows more substantial environmental improvements compared to other MSs such as ISO 9000 or the Eco-Management and Audit Scheme (EMAS) (Hojnik and Ruzzier, 2016). In fact, this is one of the reasons why firms might increasingly prefer adopting ISO 14000 rather than EMAS (Merli and Preziosi, 2018). Moreover, although ISO 9000 is focused on customers, its contribution towards fostering EPI remains unclear. Cuerva et al. (2014) observed that quality MSs are catalyzers of eco-innovation since they arise quality concerns that represent a strong stimulus that might not be addressed otherwise. Conversely, most of the authors suggest that ISO 9000 is not a driver of EPI by itself (Hojnik and Ruzzier, 2016; Terziovski and Guerrero, 2014) but it contributes to the decision of adopting this path when combined with ISO 14000 since firms can take advantage of the complementarities of both MSs (García-Quevedo et al., 2020; Papagiannakis et al., 2019; Wagner, 2007). Furthermore, although OSHAS 18001 has been scarcely related to EPI, its implementation helps in achieving the right balance between concerning on the working environment and obtaining quality and environmental gains when implemented in combination with ISO 9000 and/or ISO 14000 (Wiengarten et al., 2017b). In this line, implementing multiple MSs can be beneficial for firms in different ways (see e.g., Bernardo et al., 2015) including traditional innovation (Bernardo, 2014; Hernandez-Vivanco et al., 2016) and sustainability-oriented process and product innovations (Hernandez-Vivanco et al., 2018).

Hence, according to the existing literature, ISO 14000 promotes EPI. Nonetheless, ISO 9000 and OHSAS 18001 are not key drivers (nor inhibitors) of EPI but they can complement ISO 14000 when implemented as multiple certifications. Consequently, H1 and H2 are formulated as follows:

H1. Certifications excluding the ISO 14000 standards family do not foster or hinder eco-product innovation

H1a. ISO 9000 do not foster or hinder eco-product innovation

H1b. OHSAS 18001 certification do not foster or hinder eco-product innovation

H1c. ISO 9000 and OHSAS 18001 double certifications do not foster or hinder eco-product innovation

H2. ISO 14000 standards family promotes eco-product innovation either when implemented alone or together with other certifications

H2a. ISO 14000 promotes eco-product innovation

H2b. ISO 14000 and ISO 9000 implemented together promote eco-product innovation

H2c. ISO 14000 and OHSAS 18001 implemented together promote eco-product innovation

H2d. ISO 14000, ISO 9000 and OHSAS 18001 implemented together promote eco-product innovation

2.2. The role of slack resources in the relationship between certifications and eco-product innovation

Slack is defined as "the pool of resources in an organization that is in excess of the minimum necessary to produce a given level of organizational output" (Nohria and Gulati, 1996, p. 1246). Therefore, slack represents a cushion of resources that allows organizations to adapt more easily as required by the demands of the environment (Bourgeois, 1981), at the same time that it stimulates innovation (Leyva-de la Hiz et al., 2019; Nohria and Gulati, 1996).

Compared to traditional innovation, EPI is even more sensitive to slack because it requires significant capital investment, success is not assured and therefore risk is often higher (Berrone et al., 2013; Nohria and Gulati, 1996). However, although slack may promote EPI projects, holding slack does not necessarily initiate them (Bowen, 2002) because some firms might prefer to use slack for other purposes that might jeopardize the environment (Arora and Dharwadkar, 2011; Berrone et al., 2013). Therefore, the eco-orientation of firms is crucial to deploy slack towards EPI, where firms holding ISO 14000 show significant gains towards it according to the existing literature (Hojnik and Ruzzier, 2016; Khan et al., 2021; Papagiannakis et al., 2019; Wang et al., 2022).

The implementation of EPI with the use of slack is better achieved with the engagement of various stakeholders, including customers and employees (Huang and Chen, 2022; Papagiannakis et al., 2019; Waddock and Graves, 1997). Customer engagement is relevant not only because their demands to the market usually drive EPI (Hojnik and Ruzzier, 2016), but also because customers could get involved in the

innovation process to enhance EPI capacities even for firms lacking of slack (Chen and Liu, 2020). Therefore, by gaining customer engagement in the innovation process, the ISO 9000 standards family complement the environmental focus of ISO 14000 for firms to use slack in favor of EPI (Cuerva et al., 2014; Papagiannakis et al., 2019; Wagner, 2007). Furthermore, related to employee's engagement in EPI, OHSAS 18001 contributes to increase their awareness of the environmental aspects of business, which facilitates the use of slack to address them rather than to seek for other more profitable or less risky projects (Wiengarten et al., 2017a). Thus, OHSAS 18001 complements ISO 14000 in the development of EPI by entailing a higher level of scrutiny to meet the concerns of stakeholders from customers to society at large (Testa and D'Amato, 2017; Wiengarten et al., 2017b), thereby enabling the use of slack in favor of EPI (Huang and Chen, 2022; Waddock and Graves, 1997).

ISO 14000 offers organizations the capability to perform EPI (Hojnik and Ruzzier, 2016; Khan et al., 2021; Papagiannakis et al., 2019; Wang et al., 2022) vis-à-vis the use of critical resources (Hernandez-Vivanco et al., 2018; Khan et al., 2021), thus being more prone to deploy slack to this end. This vision is complemented by the market-oriented perspective and customer engagement obtained with ISO 9000 (Hojnik and Ruzzier, 2016; Papagiannakis et al., 2019; Wagner, 2007), as well as by the employee engagement and environmental awareness gains provided by OHSAS 18001 (Testa and D'Amato, 2017; Wiengarten et al., 2017b). Thus, both ISO 9000 and OHSAS 18001 seem to serve as a support to deploy slack to perform EPI in firms holding ISO 14000. However, by themselves (i.e., without including ISO 14000), nor ISO 9000 or OHSAS 18001 would ensure that slack is used to drive EPI since their focus lays in concerns not necessarily oriented to eco-innovation (Hojnik and Ruzzier, 2016; Terziovski and Guerrero, 2014). Consequently, H3 and H4 are stated as follows:

H3. Slack resources do not moderate the relationship between certifications and eco-product innovation in firms excluding ISO 14000 certification

H3a. Slack resources do not moderate the relationship between ISO 9000 and eco-product innovation

H3b. Slack resources do not moderate the relationship between OHSAS 18001 and eco-product innovation

H3c. Slack resources do not moderate the relationship between ISO 9000 and OHSAS 18001 double certifications and eco-product innovation

H4. Slack resources moderate positively the relationship between certifications and eco-product innovation in firms holding ISO 14000 alone or implemented together with other certifications

H4a. Slack resources moderate positively the relationship between ISO 14000 and eco-product innovation

H4b. Slack resources moderate positively the relationship between ISO 14000 and ISO 9000 double certifications and eco-product innovation

H4c. Slack resources moderate positively the relationship between ISO 14000 and OHSAS 18001 double certifications and eco-product innovation

H4d. Slack resources moderate positively the relationship between ISO 14000, ISO 9000 and OHSAS 18001 triple certifications and eco-product innovation

Fig. 1 schematizes the studied relationships. According to this model, firms holding the ISO 14000 certification, both in single or multiple certification structures (i.e., implemented together with ISO 9000 and/or OHSAS, 18001), are expected to be more prone to EPI (H2) compared to non-certified firms, especially in the cases where firms hold larger amounts of slack resources (H4). However, EPI is expected to be unaffected in firms excluding the ISO 14000 (H1) regardless of their slack resources (H3).

3. Methodology

To test the hypothesis empirically, the analysis is based on a quantitative approach. In section 3.1., the variables selection is described according to the available data for this research. Then, section 3.2. describes the studied population, the methodology to select the sample, followed by a descriptive analysis of the sample based on the selected variables. Afterwards, section 3.3. details the model specification based on a panel population-averaged logit estimation. Finally, section 3.4. describes the methods used to analyze this model to test the hypotheses empirically.

3.1. Measurement of variables

The analysis is based on the Thomson Reuters' Refinitiv® Eikon database,[1] which collects data from trusted contacts in more than 30,000 firms across more than 180 countries. It classifies the variables into one of 18 categories such as "Product Responsibility" or "Shareholders" and ranks the performance of each firm based on the indicators included in each category. To this end, Eikon follows a consistent methodology to obtain and process the data obtained from diverse sources including annual reports and trusted news, among others. With the available data in this database, the selected variables are described next.

3.1.1. Dependent variables

The "product innovation" category of the Eikon database indicates whether a firm innovated or not in (1) the design and (2) use of environmentally focused products. Relying on this category is a common approach to measure EPI. Thus, for a specific year, the EPI variable took a value of 1 if the firm innovated in any of the design or use features (similar to Papagiannakis et al., 2019).

Moreover, eco-design is often treated as a relevant stage of eco-innovation (He et al., 2018), and it is also addressed specifically by MSs (see e.g., ISO, 2020; Lewandowska and Matuszak-Flejszman, 2014). To account for potential differences in the design and use stages of EPI, both EPI-design and EPI-use were distinguished as two separate variables:

- EPI-design: equals 1 if the firm innovated in any of the design features
- EPI-use: equals 1 if the firm innovated in any of the use features

Thus, three dependent variables were included: i) EPI as a whole (including both the design and use stages), ii) EPI-design and iii) EPI-use. The details of the items used to measure these variables are included in the Appendix.

3.1.2. Explanatory and moderating variables

The certifications held by a firm denote the main explanatory variable. Following Hernandez-Vivanco et al. (2019), the seven possible combinations of the three standards included in this research, including not holding any certification are captured in the Certifications categorical variable.

Regarding slack, the literature distinguishes two main types of resources, namely high discretion (available or unabsorbed liquid resources) or low discretion (absorbed costs) slack (Bourgeois and Singh, 1983; Tan and Peng, 2003). Unabsorbed financial slack is easily redeployed when needed into new projects (Tan and Peng, 2003), including product innovation (Nohria and Gulati, 1996; Voss et al., 2008).

[1] For more information about this database, please refer to Refinitiv Eikon website https://eikon.thomsonreuters.com.

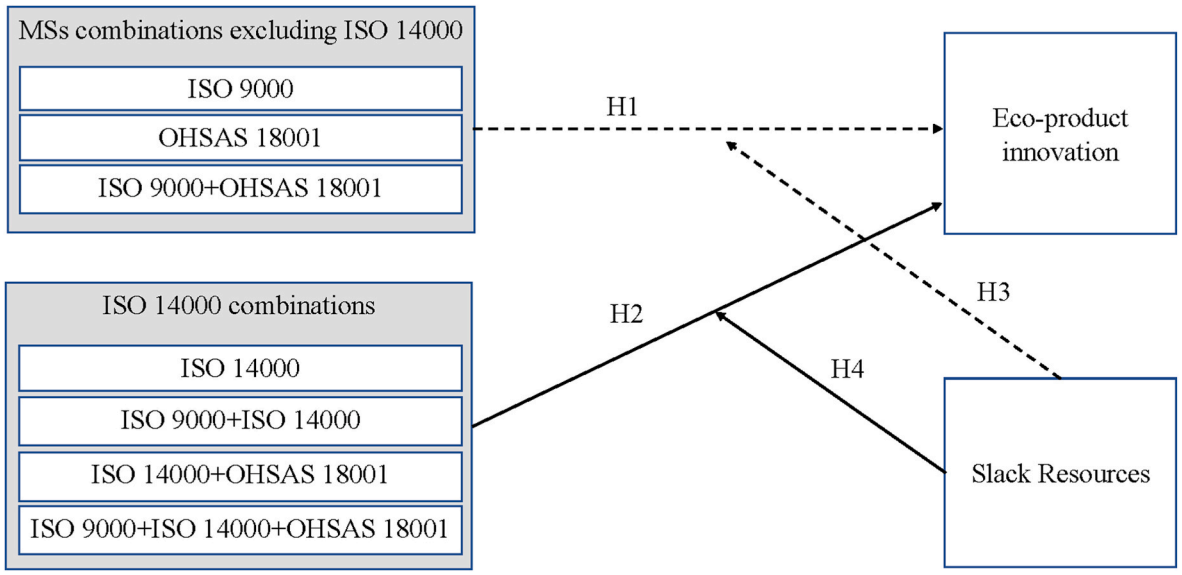

Fig. 1. Model scheme relating certifications, slack and eco-product innovation.
Note: The dotted lines represent relationships that are expected to be not significant.

Moreover, it might have beneficial outcomes compared to the absorbed resources as predictors of future performance (Tan and Peng, 2003). Therefore, this research focuses on available (high discretion) financial slack as a measure of excess resources within organizations (Arora and Dharwadkar, 2011; Leyva-de la Hiz et al., 2019; Tariq et al., 2022; Voss et al., 2008). Following the relevant literature on this topic, available financial slack is measured as the ratio between current assets and current liabilities (Leyva-de la Hiz et al., 2019; Papagiannakis et al., 2019). Given the non-normality of this variable, the logarithm was applied (e.g., Arora and Dharwadkar, 2011; Berrone et al., 2013).

3.1.3. Control variables

Stakeholder involvement is controlled given its importance to EPI (Feng et al., 2022; Papagiannakis et al., 2019; Waddock and Graves, 1997). Firms' commitment towards responsible products offerings in terms of health & safety, integrity and data privacy is also controlled (Papagiannakis et al., 2019) due to its importance in green supply chains (Feng et al., 2022). Both Stakeholder Engagement and Product Responsibility variables were taken from the scores of their respective categories provided by Eikon, which rankings are between 0 and 100. Moreover, investment in environmental R&D – for example, to sponsor environmental patents (Leyva-de la Hiz et al., 2019; Wagner, 2007) – promotes EPI so its effect was controlled as a dummy variable equal to 1 if companies invested in environmental R&D and 0 otherwise. The effect of size is controlled using the logarithm of the number of employees (Papagiannakis et al., 2019). Finally, Sector dummies based on the Global Industry Classification Standard and Region dummies considering the headquarters were included to account for the context of the analyzed firms (García-Quevedo et al., 2020; Hernandez-Vivanco et al., 2018).

3.2. Population and sample selection

The ISO 9000, ISO 14000 and OHSAS18001 certifications are the main variables of interest. Accordingly, the initial database consisted of 50,360 observations obtained from 6111 firms with non-missing information about such standard families. Then, observations containing missing values and outliers in any of the variables included in this study were dropped. This process resulted into an unbalanced panel composed of 2910 firms between years 2006 and 2020. Due to the use of lagged variables as described in the model specification (see section 3.3.), year 2006 was omitted in the estimations of the econometrical models, leading to 2834 firms to be finally included in this study.

The adoption of certifications is dynamic across years (Hernandez-Vivanco et al., 2019), and the involved strategies might be relevant to innovation by allowing higher levels of MSs integration (Bernardo et al., 2012; Hernandez-Vivanco et al., 2018). Thus, it is worth describing the different certification strategies used by the firms in the selected sample. Following the methods described in Bernardo et al. (2012), it is found that 75.3% of firms adopted ISO 14000 firstly, which suggests that the studied companies might be highly exposed to institutional pressures due to their relevance in their markets and their international operations scope (García-Quevedo et al., 2020). This is an interesting property of the analyzed sample because most studies have identified samples where ISO 9000 typically precedes ISO 14000 in their certification strategies (Bernardo et al., 2012; Hernandez-Vivanco et al., 2019; Papagiannakis et al., 2019; Wiengarten et al., 2017b). Finally, 20.9% of the certified firms de-certified at some point, mainly of ISO 9000 (45.2%), followed by ISO 14001 (29.9%) and OHSAS 18001 (24.5%).

Table 1 describes the summary statistics of the continuous variables, where it can be seen that, on average, 51.9% of firms perform EPI, 50.4% EPI-design and 56.6% EPI-use. Moreover, the untransformed values for firm size averages 9691 employees, which corresponds to very large firms and therefore their environmental impact is likely to be considerable.

Table 2 shows a more detailed description of EPI for each of the different levels of the categorical variables. It is evidenced that the mean values of EPI are higher for firms holding ISO 14000. Conversely, firms not holding any certification reflect the lowest EPI. Additionally, 71.7% of firms holding triple certifications implement EPI, which is also the highest EPI mean compared to the other categories. Triple certifications are also the most implemented certifications' structure, accounting for 33.52% of the observations. Moreover, 86.6% of firms investing in environmental R&D implement EPI in contrast to the 48.2% observed in firms not investing on it. The differences on EPI depending on the sector are also evident, where more than 50% of firms in the Consumer Discretionary, Industrial, Information Technologies (IT), Materials and Utilities sectors implement EPI, in contrast to the lower EPI means of the Communication Services, Consumer Staples, Energy, Financial, Health Care and Real State sectors. Besides, 50.9% of Asian and 52.5% of European firms implement EPI. Finally, EPI has been increasingly implemented by these firms during the studied time-span.

Table 1
Continuous variables summary statistics.

Continuous variables	Mean	Median	Std. Dev.	Std. error of the mean	Min	Max
EPI	0.519	1	0.500	0.003	0	1
EPI-design	0.504	1	0.500	0.003	0	1
EPI-use	0.566	1	0.496	0.003	0	1
$Slack_{t-1}$ (log)	0.360	0.332	0.654	0.004	−5.443	4.497
Stakeholders' $engagement_{t-1}$	37.213	54.286	36.838	0.248	0	98.571
Product $Responsibility_{t-1}$	50.126	53.571	33.318	0.224	0	99.888
Size (log)	9.179	9.270	1.725	0.012	0	14.070

Note: N = 22,056; 2,834 firms. Source: Own Elaboration.

Table 2
Categorical variables summary statistics and mean values of EPI.

Categorical variables	Code	Freq.	Percent	Cum.	Mean values of EPI		
					EPI	EPI design	EPI use
$Certifications_{t-1}$							
No	0 (ref)	5522	25.04	25.04	0.235	0.226	0.282
ISO9000	1	870	3.94	28.98	0.359	0.342	0.397
ISO14000	2	1947	8.83	37.81	0.549	0.536	0.619
OHSAS18001	3	1259	5.71	43.52	0.373	0.354	0.419
ISO9000+ISO14000	4	2431	11.02	54.54	0.64	0.629	0.687
ISO9000+OHSAS18001	5	359	1.63	56.17	0.407	0.398	0.465
ISO14000+OHSAS18001	6	2275	10.31	66.48	0.581	0.563	0.642
Triple	7	7393	33.52	100	0.711	0.693	0.749
$Environmental\ R\&D_{t-1}$							
No	0 (ref)	19994	90.65	90.65	0.482	0.467	0.530
Yes	1	2062	9.35	100	0.866	0.850	0.904
Sector							
Communication Services	0 (ref)	1655	7.5	7.5	0.369	0.315	0.450
Consumer Discretionary	1	3183	14.43	21.94	0.509	0.503	0.554
Consumer Staples	2	1766	8.01	29.94	0.351	0.323	0.427
Energy	3	1161	5.26	35.21	0.382	0.359	0.438
Financials	4	664	3.01	38.22	0.230	0.232	0.248
Health Care	5	1490	6.76	44.97	0.238	0.236	0.272
Industrials	6	5248	23.79	68.77	0.662	0.652	0.701
Information Technology	7	1794	8.13	76.9	0.671	0.639	0.680
Materials	8	2527	11.46	88.36	0.629	0.631	0.660
Real Estate	9	1418	6.43	94.79	0.429	0.438	0.503
Utilities	10	1150	5.21	100	0.663	0.630	0.746
Region							
Asia	0 (ref)	10980	49.78	49.78	0.509	0.500	0.542
Europe	1	11076	50.22	100	0.525	0.505	0.586
Year							
2007	0 (ref)	898	4.07	4.07	0.249	0.210	0.340
2008	1	957	4.34	8.41	0.406	0.399	0.492
2009	2	1062	4.82	13.23	0.474	0.441	0.575
2010	3	1186	5.38	18.6	0.498	0.459	0.602
2011	4	1409	6.39	24.99	0.496	0.472	0.588
2012	5	1476	6.69	31.68	0.526	0.495	0.597
2013	6	1427	6.47	38.15	0.533	0.508	0.594
2014	7	1520	6.89	45.04	0.537	0.520	0.583
2015	8	1614	7.32	52.36	0.534	0.526	0.569
2016	9	1649	7.48	59.84	0.546	0.535	0.571
2017	10	1726	7.83	67.66	0.550	0.545	0.570
2018	11	2070	9.39	77.05	0.534	0.529	0.551
2019	12	2545	11.54	88.59	0.543	0.542	0.559
2020	13	2517	11.41	100	0.577	0.576	0.596

Note: N = 22,056; 2,834 firms. Source: Own Elaboration.

Table 3 shows the correlations between all the studied variables. Certifications, stakeholders' engagement, environmental R&D, product responsibility, size, sector and year are positively correlated to EPI, whereas slack is negatively correlated. Moreover, the region is positively correlated to EPI-use whereas it is not correlated to EPI-design.

Finally, a detailed description of the variables obtained from the Refinitiv Eikon database is included in the Appendix.

3.3. Model specification

Since the dependent variables EPI, EPI-design and EPI-use are binary variables, a logit approach is used. Heteroskedasticity of the panel data was accounted by estimating models based on heteroskedasticity-robust standard errors (Wooldridge, 2010). To this end, the population-averaged logit estimation was performed. This approach provides a more useful approximation of the truth compared to other methods for this case, mainly because EPI of firms operating in the same sector and region may be correlated, which would violate independence

Table 3
Correlation coefficients.

Variable	1	2	3	4	5	6	7	8	9	10	11	12
1.EPI	1											
2.EPI design	0.937	1										
3.EPI use	0.903	0.842	1									
4.Certifications$_{t-1}$	0.359	0.352	0.350	1								
5.Slack (log)$_{t-1}$	−0.03	−0.026	−0.06	−0.015**	1							
6.Stakeholders' engagement$_{t-1}$	0.241	0.231	0.250	0.306	−0.100	1						
7.Environmental R&D$_{t-1}$	0.223	0.222	0.220	0.166	0.025	0.09	1					
8.Product responsibility$_{t-1}$	0.318	0.315	0.320	0.461	−0.080	0.310	0.153	1				
9.Size (log)	0.262	0.251	0.270	0.293	−0.200	0.250	0.170	0.253	1			
10.Sector	0.164	0.175	0.160	0.172	0.025	0.040	0.093	−0.03	−0.070	1		
11.Region	0.018	0.007^{ns}	0.050	0.055	−0.140	0.060	−0.180	0.110	−0.090	−0.027	1	
12.Year	0.093	0.115	0.030	0.099	0.030	0.130	−0.080	0.190	−0.080	−0.001^{ns}	−0.001^{ns}	1

Note: No asterisk $p < 0.01$, **$p < 0.05$; ns > 0.1. N = 22,056; 2,834 firms. Source: Own Elaboration.

assumptions made by traditional regression procedures (Hubbard et al., 2010). Accordingly, the estimated effects are based on the average firms' behavior. Thus, following the specialized literature (e.g., Hubbard et al., 2010; Neuhaus et al., 1991), the panel population-averaged logit model is specified as follows:

$$\text{logit } P\left(Y_{ij}=1\middle|\mathbf{X}_{ij}\right)=\alpha+\boldsymbol{\beta}\mathbf{X}_{ij} \quad (1)$$

Where Y denotes EPI, EPI-design and EPI-use; $i = 1, \ldots, N$ and $j = 1, \ldots, T$ represent, respectively, the firms and time periods; X_{ij} stand for the set of main and control variables, including the Certifications*Slack term to account for the moderating effect of slack; logit $P(Y_{ij}=1|\mathbf{X}_{ij})$ is the logistic function for the conditional probability of having a positive outcome given a set of X_{ij} parameters; α is a fixed constant and $\boldsymbol{\beta}$ is a vector of the estimated coefficients of the logit regression. Moreover, X_{ij} includes lagged variables in t-1 for Certifications, Slack, Stakeholders' engagement, Environmental R&D and Product responsibility to account for the gradual (i.e., non-instantaneous) effect they might have on EPI (see e.g., Berrone et al., 2013; Papagiannakis et al., 2019). Finally, the Size, Sector and Region were not lagged since their effect is often deemed to occur on the same year according to the existing literature (see e.g., Hernandez-Vivanco et al., 2019; Leyva-de la Hiz et al., 2019; Testa and D'Amato, 2017).

3.4. Methods for the analysis of the logit models

The coefficients obtained directly from logit regressions are not marginal effects and do not have a probability interpretation given their non-linear nature; therefore, further analysis should be performed to interpret their results (Hubbard et al., 2010; Neuhaus et al., 1991; Uberti, 2022). In this paper, the analysis was carried out in two steps using the statistical software Stata 17.0., following the suggestions of Uberti (2022).

Step 1 is designed to measure the direct effects of certifications on EPI according to H1 and H2. The marginal effects were calculated as the change in the probability of having a positive outcome given the change of the variable of interest x_i (i.e., $\partial P/\partial xi$) using the *dydx* method for all the variables. For continuous variables, these coefficients represent the impact on the probability of EPI [i.e., $P(Y_{ij}=1|x_i,X_i)$] of a "marginal" (infinitesimally small) change in x_i (Uberti, 2022, pp. 61–62). For categorical variables, for a given level m, these coefficients represent the discrete change, on average, from the probability of EPI in the reference level r [i.e., $P(Y_{ij}=1|x_i=m,X_i) - P(Y_{ij}=1|x_i=r,X_i)$]. The latter calculation is also known as the contrast of margins (Uberti, 2022, pp. 66–67).

Step 2 analyzes the moderating effects of slack to test H3 and H4. Thus, firstly, the average predictive probabilities of EPI given each combination of certifications and level of slack resources was plotted. Then, in order to be able to infer on the implications of this interaction, a more detailed analysis was performed. Hence, secondly, the difference in the probability of EPI between holding a specific certification and not holding any certification (i.e., the contrast of margins for the Certifications variable) was plotted as a function of slack, the effect modifier, averaging over the remaining covariates. This contrast of margins was plotted for all the combinations of certifications based on a 95% confidence (Uberti, 2022, pp. 70–75).

4. Results and discussion

Table 4 shows the results obtained from the logit model according to equation (1). For EPI, EPI-design and EPI-use, three models were estimated, including only control variables (Models 1, 4 and 7), the direct effect of certifications (Models 2, 5 and 8) and the full model adding the moderation of slack resources (Models 3, 6 and 9). The Wald test for all models is significant, and the Wald-type joint significant tests support that adding the main variables is adequate.

For the interpretation of the logit estimations, firstly, the results of *Step 1* related to the marginal effects to test H1 and H2 are presented and discussed. The marginal effects are shown in Table 5. According to these results, holding the ISO 9000 or the ISO 9000+OHSAS 18001 certifications do not affect the probability of EPI compared to firms that do not hold any certification, as predicted by H1a and H1c. Moreover, holding the OHSAS 18001 certification represents a 5.4% increase in the probability of EPI-design and 3.9% in EPI-use, which was not expected according to H1b. Therefore, H1 is partially supported. The lack of direct effects of ISO 9000 has been reported in previous research (Wagner, 2007) and is in line with H1. Conversely, the unexpected benefits of OHSAS 18001 might be attributed to the increased awareness of employees towards improving environmental performance (Wiengarten et al., 2017b).

Regarding the certification structures that include ISO 14000 (related to H2), this standards family increase firms' likelihood of reporting positive EPI-design outcomes by 13.1% when implemented alone, 12.4% when implemented in combination with ISO 9000, 14.1% in combination with OHSAS 18001 and 12.1% in combination with both. Related to EPI-use, ISO 14000 increase firms' loglikelihood towards EPI by 13.4% when implemented alone, 11.6% when implemented in combination with ISO 9000, 13.1% in combination with OHSAS 18001 and 13.4% in combination with both. These results support H2 (i.e., H2a, H2b, H2c and H2d), suggesting that ISO 14000 is the main driver of EPI even when implemented in combination with ISO 9000 and/or OHSAS 18001. These outcomes are in line with the existing literature for single (see e.g., Al-Shami and Rashid, 2022; Hojnik and Ruzzier, 2016; Wang et al., 2022), double (García-Quevedo et al., 2020; Papagiannakis et al., 2019; Wagner, 2007) and triple certifications (Bernardo, 2014; Hernandez-Vivanco et al., 2018).

Regarding the control variables, firms investing in Environmental

Table 4
Logit model estimations.

Variables	EPI			EPI design			EPI use		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
Main variables									
Certifications$_{t-1}$*Slack$_{t-1}$ (log)									
ISO9000			0.167			0.156			0.207
			(0.166)			(0.177)			(0.146)
ISO14000			−0.013			0.066			−0.053
			(0.132)			(0.153)			(0.137)
OHSAS18001			−0.023			−0.037			0.063
			(0.129)			(0.140)			(0.150)
ISO9000+ISO14000			**0.247***			0.181			**0.336****
			(0.130)			(0.133)			(0.131)
ISO9000+OHSAS18001			**0.396***			0.321			**0.490****
			(0.218)			(0.209)			(0.201)
ISO14000+OHSAS18001			**0.231***			**0.258****			**0.219***
			(0.128)			(0.127)			(0.129)
Triple			**0.254*****			**0.228****			**0.218****
			(0.094)			(0.097)			(0.088)
Certifications$_{t-1}$									
ISO9000		0.140	0.085		0.141	0.087		0.141	0.070
		(0.118)	(0.130)		(0.122)	(0.131)		(0.105)	(0.114)
ISO14000		**0.667*****	**0.669*****		**0.638*****	**0.615*****		**0.637*****	**0.655*****
		(0.088)	(0.099)		(0.093)	(0.110)		(0.089)	(0.098)
OHSAS18001		**0.265****	**0.266****		**0.271****	**0.277****		**0.182***	0.160
		(0.106)	(0.115)		(0.114)	(0.124)		(0.108)	(0.112)
ISO9000+ISO14000		**0.587*****	**0.497*****		**0.606*****	**0.542*****		**0.554*****	**0.428*****
		(0.095)	(0.104)		(0.098)	(0.107)		(0.091)	(0.099)
ISO9000+OHSAS18001		−0.055	−0.180		0.089	−0.014		0.009	−0.149
		(0.174)	(0.196)		(0.166)	(0.191)		(0.159)	(0.181)
ISO14000+OHSAS18001		**0.654*****	**0.583*****		**0.675*****	**0.596*****		**0.615*****	**0.546*****
		(0.092)	(0.097)		(0.096)	(0.103)		(0.091)	(0.100)
Triple		**0.567*****	**0.486*****		**0.586*****	**0.512*****		**0.627*****	**0.557*****
		(0.089)	(0.097)		(0.090)	(0.097)		(0.086)	(0.092)
Control variables									
Slack$_{t-1}$ (log)	−0.042	−0.043	**−0.147****	−0.003	−0.003	**−0.106***	−0.040	−0.042	**−0.150*****
	(0.043)	(0.044)	(0.058)	(0.045)	(0.046)	(0.061)	(0.042)	(0.043)	(0.055)
Stakeholders$_{t-1}$	**0.004*****	**0.003*****	**0.003*****	**0.003*****	**0.003*****	**0.003*****	**0.004*****	**0.003*****	**0.003*****
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Environmental R&D$_{t-1}$	**0.342*****	**0.334*****	**0.336*****	**0.311*****	**0.304*****	**0.306*****	**0.331*****	**0.326*****	**0.332*****
	(0.079)	(0.078)	(0.077)	(0.081)	(0.079)	(0.079)	(0.084)	(0.084)	(0.084)
Product Responsibility$_{t-1}$	**0.007*****	**0.006*****	**0.006*****	**0.006*****	**0.005*****	**0.005*****	**0.008*****	**0.006*****	**0.006*****
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Size (log)	**0.250*****	**0.228*****	**0.230*****	**0.250*****	**0.224*****	**0.225*****	**0.247*****	**0.223*****	**0.222*****
	(0.029)	(0.028)	(0.028)	(0.029)	(0.028)	(0.028)	(0.027)	(0.026)	(0.026)
Region (Europe)	**0.184****	**0.144***	**0.148***	0.117	0.068	0.075	**0.309*****	**0.280*****	**0.280*****
	(0.081)	(0.081)	(0.081)	(0.082)	(0.082)	(0.082)	(0.078)	(0.077)	(0.077)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	**−5.356*****	**−5.387*****	**−5.332*****	**−5.652*****	**−5.630*****	**−5.586*****	**−4.619*****	**−4.546*****	**−4.474*****
	(0.333)	(0.336)	(0.333)	(0.337)	(0.340)	(0.337)	(0.298)	(0.297)	(0.294)
Number of observations	22,056	22,056	22,056	22,056	22,056	22,056	22,056	22,056	22,056
Number of firms	2834	2834	2834	2834	2834	2834	2834	2834	2834
Wald χ^2 model	1009.307***	1070.493***	1087.133***	987.349***	1048.281***	1060.432***	943.256***	1020.845***	1031.850***
Model df	29	36	43	29	36	43	29	36	43
Wald joint significance test		91.92***	72.56***		78.71***	56.55***		87.46***	71.61***

Note: ***p < 0.01; **p < 0.05; *p < 0.10. Source: Own elaboration.

R&D are significantly more innovative in terms of both EPI-design and EPI-use. Moreover, changes in Stakeholders' Engagement, Product responsibility and Firm's Size increase the probability of EPI, as expected from the existing literature (Leyva-de la Hiz et al., 2019; Papagiannakis et al., 2019; Wagner, 2007). European firms are found more prone to EPI-use compared to Asians, although they both perform similarly in terms of EPI-design. Thus, the differences between regions related to their corresponding regulations and institutional pressures (Bansal and Bogner, 2002; García-Quevedo et al., 2020), seem to be more related to EPI-use than EPI-design. Regarding slack, results do not show a direct impact because there might be different behaviors depending on the implemented certifications as predicted by H3 and H4. Thus, the interaction term is analyzed next.

To begin with Step 2 of the analysis, related to H3 and H4, Fig. 2 shows the average predictive probabilities of EPI depending on the certifications and slack resources. A visual inspection suggests potential different behaviors of the effect of MSs on EPI depending on the slack, which needs to be further examined.

The interaction term between Certifications and Slack is intended to describe what the Certification's marginal effect is for various degrees of Slack. In the cases where the probability of a specific level is equal to the probability of the reference level, zero is included in the confidence interval; otherwise, there are significant differences. The results of these calculations are presented in Figs. 3–5 for EPI, EPI-use, and EPI-design, respectively.

To interpret these results, firstly, the certification structures that exclude ISO 14000 (related to H3) are presented and discussed. According to Fig. 3, firms holding the ISO 9000 (single) certification do not have EPI benefits regardless of the slack. Fig. 4 shows that this also occurs in terms of EPI-design. However, in terms of EPI-use, represented

Table 5
Marginal effects of the logit model.

Variables	EPI	EPI-design	EPI-use
$Certifications_{t-1}$			
ISO9000	0.029	0.028	0.030
	(0.024)	(0.025)	(0.023)
ISO14000	**0.137*****	**0.131*****	**0.134*****
	(0.018)	(0.019)	(0.019)
OHSAS18001	**0.053****	**0.054****	**0.039***
	(0.022)	(0.023)	(0.023)
ISO9000+ISO14000	**0.121*****	**0.124*****	**0.116*****
	(0.020)	(0.02)	(0.019)
ISO9000+OHSAS18001	-0.009	0.020	0.005
	(0.035)	(0.034)	(0.033)
ISO14000+OHSAS18001	**0.137*****	**0.141*****	**0.131*****
	(0.019)	(0.02)	(0.019)
Triple	**0.119*****	**0.121*****	**0.134*****
	(0.019)	(0.019)	(0.018)
$Slack_{t-1}$ (log)	-0.001	0.006	-0.002
	(0.009)	(0.010)	(0.009)
$Stakeholders_{t-1}$	**0.001*****	**0.001*****	**0.001*****
	(0.000)	(0.000)	(0.000)
Environmental $R\&D_{t-1}$	**0.067*****	**0.061*****	**0.066*****
	(0.015)	(0.016)	(0.016)
Product $Responsibility_{t-1}$	**0.001*****	**0.001*****	**0.001*****
	(0.000)	(0.000)	(0.000)
Size (log)	**0.046*****	**0.045*****	**0.045*****
	(0.005)	(0.005)	(0.005)
Region (Europe)	**0.029***	0.015	**0.056*****
	(0.016)	(0.016)	(0.015)
Sector dummies	Yes	Yes	Yes

Note: ***p < 0.01; **p < 0.05; *p < 0.10. Coefficients are the marginal effects. Delta-method standard error in parenthesis. Reference levels are Certifications: No certification; Environmental R&D: No; Region: Asia; Sector: Communication Services. Source: Own elaboration.

in Fig. 5, firms might obtain slightly better results than non-certified firms for medium-high levels of slack, although its contribution is limited (p<10%). Thus, H3a is partially supported since non-significant effects were expected. Similarly, regarding the OHSAS 18001 certification, firms might be slightly more prone to EPI-design in a very narrow region of intermediate levels of slack. Nonetheless, OHSAS 18001 seems not to be relevant for EPI-use. Thus, H3b is partially supported. Although some benefits of ISO 9000 and OHSAS 18001 are found, these occur at limited levels of slack or modest levels of significance, so these certifications seem not to be drivers of EPI by themselves (Hojnik and Ruzzier, 2016).

Moreover, firms holding ISO 9000+OHSAS 18001 double certifications have two different behaviors for EPI-design and EPI-use. In terms of EPI-design, this double certification does not have a significant role as predicted by H3c. However, EPI-use is subject to antagonistic responses depending on the level of slack. For low levels of slack, these firms are significantly less prone to EPI, while for high levels of slack these firms are significantly more prone EPI. These results contradict H3c due to the negative consequences of ISO 9000+OHSAS 18001 on EPI-use at low levels of slack, but also due to the positive outcomes at high levels of slack. Thus, H3c is partially supported (supported for EPI-design and not supported for EPI-use). These findings might be associated with the nature of these certifications focused on gaining internal efficiency by promoting process innovation (Terziovski and Guerrero, 2014; Wagner, 2007), operational efficiency and employees' safety (Lo et al., 2014; Naveh and Marcus, 2007; Wiengarten et al., 2017a). As firms allocate more resources to activities that enhance internal efficiency, slack will be used to those ends rather than to engage in environmental responses (Cheng and Kesner, 1997). This might hinder EPI-use in firms with low levels of slack as they would focus on improving financial performance and conserving slack (Voss et al., 2008), while conforming to meet

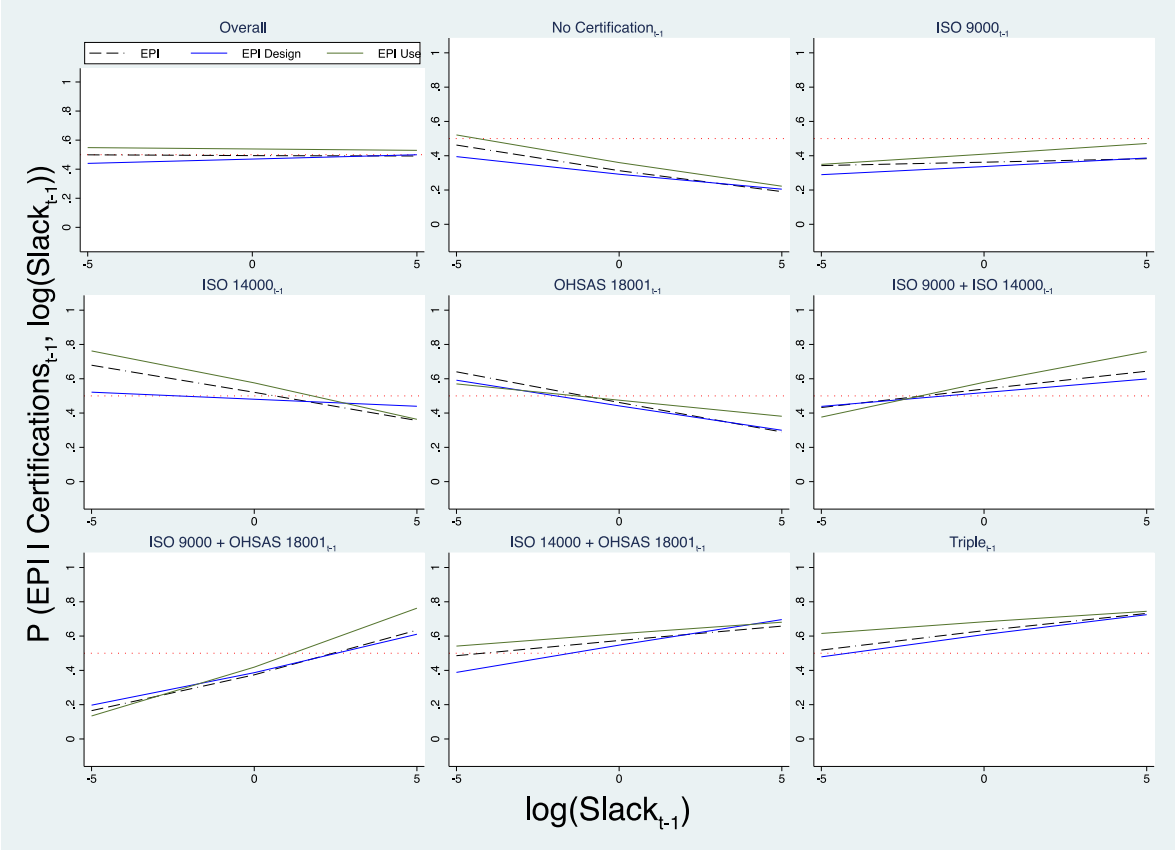

Fig. 2. EPI, EPI-design and EPI-use predicted probabilities per Certification and levels of Slack.
Source: Own elaboration.

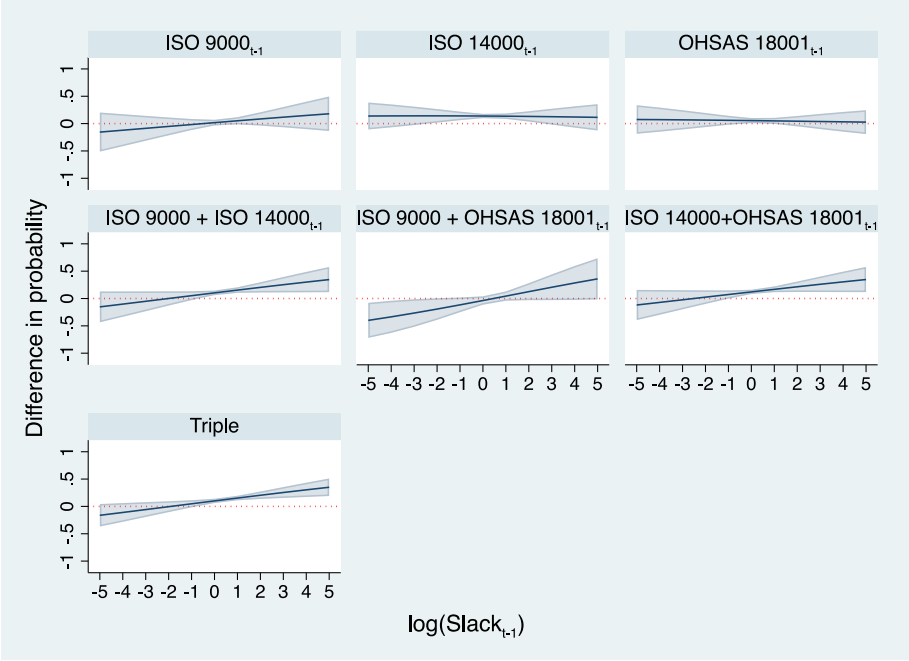

Fig. 3. Average marginal effects of Certifications on EPI.
Source: Own elaboration.

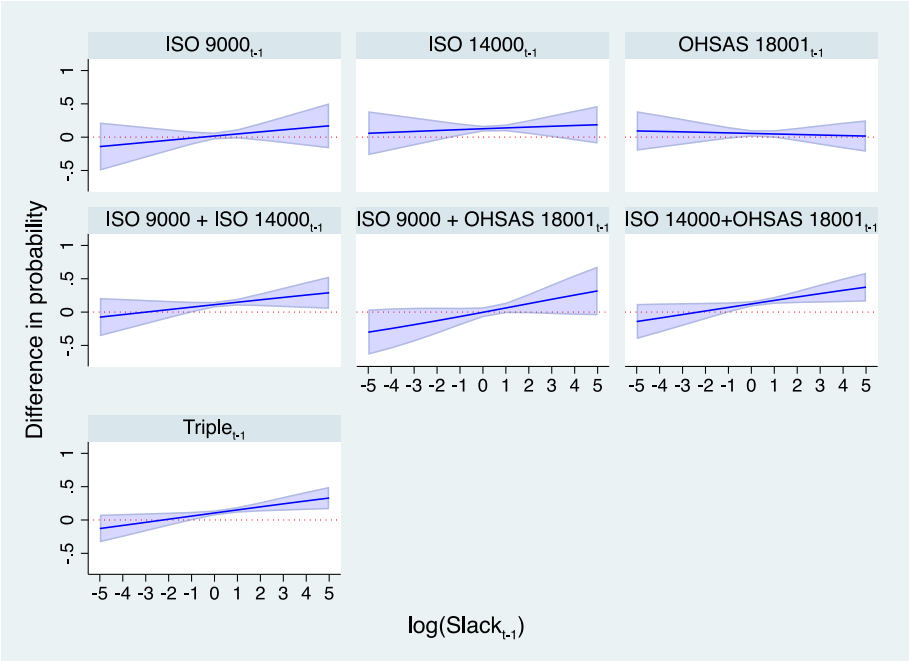

Fig. 4. Average marginal effects of Certifications on EPI-design.
Source: Own elaboration.

stakeholders' minimum standards (Arora and Dharwadkar, 2011). Once firms succeed to perform better, they leverage the customers' and employees' engagement hosted by these standards to increasingly respond in terms of EPI-use by exploiting their existing products with environmental features (Voss et al., 2008). Moreover, these certifications seem not to have a significant role for EPI-design due to the limited environmental focus of these standards, which limits the capacity of firms to explore new environmental products (Voss et al., 2008). Hence, knowing that these ventures could potentially end up in unviable or unfinished projects (Nohria and Gulati, 1996), firms holding ISO 9000+OHSAS 18001 do not promote or hinder EPI-design.

Regarding certification structures that include ISO 14000 (related to H4), results suggest that firms holding ISO 14000 (single) certification are significantly more likely to respond to EPI at intermediate levels of slack but not at low or high levels. These results are consistently observed in both EPI-design and use. Thus, H4a is partially supported.

Concerning multiple certifications that include the ISO 14000 standards family, results suggest that these firms are, on average, increasingly more prone to EPI-design and EPI-use as slack increases from intermediate to high levels, in line with H4b, H4c and H4d. However, at

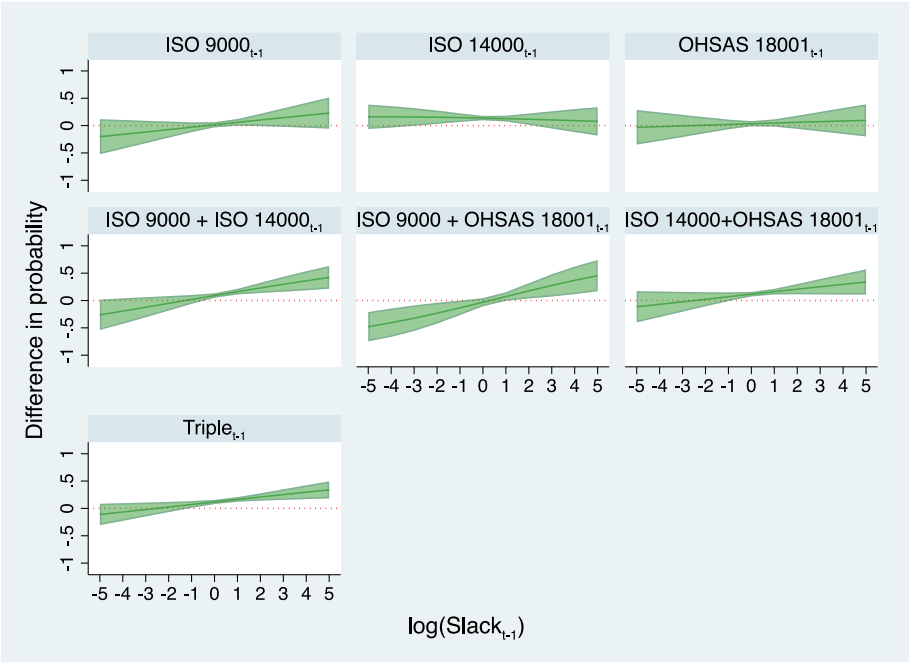

Fig. 5. Average marginal effects of Certifications on EPI-use.
Source: Own elaboration.

low levels of slack there are no significant differences with non-certified firms, which was not expected in these hypotheses. Therefore, H4b, H4c and H4d are partially supported.

Then, according to results above, H4 is partially supported. More specifically, firms seem to require having some slack to invest in EPI projects (Li, 2014). Thus, for low levels of slack, firms would prefer investing on focused environmental innovations (Leyva-de la Hiz et al., 2019) and to improve firms' internal performance (Cheng and Kesner, 1997) up to the point they have enough slack to engage in EPI. This seems to work for firms holding multiple certifications that include ISO 14000. However, when ISO 14000 is implemented alone in firms with high slack, they incur in the risk to engage on 'bad' projects that not necessarily meet market requirements (Nohria and Gulati, 1996). Firms seem to overcome this risk by including ISO 9000 as it contributes not only with the market vision but also with financial performance gains (Hernandez-Vivanco et al., 2019). Moreover, including OHSAS 18001 contributes to EPI by promoting the allocation of resources in projects that benefit environmental and occupational health & safety, which would otherwise have been allocated to other ends that promote profitability more directly (Wiengarten et al., 2017a).

Confirming H4 in multiple certification structures for both EPI-design and EPI-use is particularly relevant, since it implicates that, by reducing the perceived risk of EPI projects through the increase of environmental awareness (ISO 14000) and the engagement of customers (ISO 9000) and employees (OHSAS, 18001) (Lo et al., 2014; Naveh and Marcus, 2007; Waddock and Graves, 1997), firms leverage the use of slack to invest in product exploration (design) and product exploitation (use), complementing the discussion proposed by Voss et al. (2008). Further examination is required to confirm the potentially ambidextrous characteristic of these firms and its implications for EPI.

Triple certifications are especially relevant to this discussion for two main reasons. Firstly, because the three standards implemented together can harness firms' strategic focus on the concerns of customers, employees and the environment, which is necessary to respond to their needs and use slack to foster EPI (Bai et al., 2021; Waddock and Graves, 1997). Secondly, because triple certifications are being increasingly adopted by firms, which are also more likely to integrate their MSs (Bernardo et al., 2012; Salomone, 2008). Thus, the EPI gains obtained through triple certifications might be attributed, at least partially, to the integration of MSs (Bernardo, 2014; Hernandez-Vivanco et al., 2018). Further research is needed to confirm the role of the integration of MSs for EPI.

Another relevant topic to discuss is related to the certifications' withdrawals found in the studied sample that are increasing occurring globally (ISO, 2021). This study includes these observations but does not focus on analyzing the effects that certifications withdrawals have on EPI (Cândido and Ferreira, 2021; Heras-Saizarbitoria et al., 2016). Thus, further research is required to fill this gap.

Finally, Table 6 summarizes the main findings of this research contrasting the results with the hypotheses presented.

5. Conclusions

The aim of this article is to analyze whether certified firms are more prone to EPI than non-certified firms, considering the moderating role of slack resources. To this end, three standard families are studied, namely, ISO 9000, ISO 14000, and OHSAS 18001.

Results suggest that ISO 14000 is the main driver of EPI, promoting the development of design and use eco-oriented features in these products, even when implemented in combination with ISO 9000 and/or OHSAS 18001. Slack resources play a significant role on this relationship by leveraging the certifications' benefits when firms are profitable enough to generate intermediate or high levels of slack. However, at low levels of slack certified firms obtain similar EPI outcomes compared to non-certified. Presumably, certified firms might prefer investing slack to improve their internal efficiency or to work on focused environmental projects as means to ensure their resilience, although without hampering EPI. Since these specific dynamics were not assessed, further research is required on this topic. Moreover, across the different MSs combinations, the triple certification is relevant because it is gaining popularity in diffusion, and because it gathers the customers', employees', and environmental visions, so that firms can balance them properly to promote EPI.

The main contribution of this study is that, to the best of the authors' knowledge, this is one of the first articles to analyze different possible combinations of ISO 9000, ISO 14000 and OHSAS 18001, and their

Table 6
Contrast of hypotheses.

Certifications		Direct relationships (H1 and H2)		Moderating role of slack (H3 and H4)			
		Hypotheses	Result; Conclusion	Hypotheses	Result; Conclusion		
					Low slack	Intermediate slack	High slack
Excluding ISO 14000	ISO 9000	H1a	ns; Supported	H3a	ns; Supported	ns[2]; Supported	ns; Supported
	ISO 18001	H1b	(+)[1]; Partially supported	H3b	ns; Supported	(+)[3]; Partially supported	ns; Supported
	ISO 9000+OHSAS 18001	H1c	ns; Supported	H3c	(−)[a]; Partially supported	(−/+)[a]; Partially supported	(+)[a]; Partially supported
Including ISO 14000	ISO 14000	H2a	(+); Supported	H4a	ns; Not supported	(+); Supported	(+); Supported
	ISO 9000+ISO 14000	H2b	(+); Supported	H4b	ns; Not supported	(+); Supported	(+); Supported
	ISO 14000+OHSAS 18001	H2c	(+); Supported	H4c	ns; Not supported	(+); Supported	(+); Supported
	Triple	H2d	(+); Supported	H4d	ns; Not supported	(+); Supported	(+); Supported

Note: (+) positive relationship with EPI; (−) negative relationship; ns not significant.
[1] Significantly different of non-certified firms, mainly for EPI-design ($p < 0.05$) and more limited for EPI-use ($p < 0.10$).
[2] There might be EPI-use benefits at concrete points ($p < 0.10$).
[3] Significant benefits ($p < 0.05$) in EPI-design for a very narrow region.
[a] Supported for EPI-design (ns), but not supported for EPI-use. Worse EPI-use outcomes than non-certified firms at low levels of slack switching to positive outcomes at the intermediate level which keep growing as slack increases.

association with EPI, as well as the role of slack resources in moderating these relationships.

The main managerial implications of this work are based on the importance of adopting multiple MSs to favor EPI. Therefore, firms could implement MSs to promote eco-innovation. If they do, ISO 14000 helps, but the highest benefits come from multiple certifications. Through them, firms might benefit from managing slack well enough to avoid engaging in risky/unsuccessful EPI projects as well as to increase EPI outcomes when firms are profitable enough to generate high levels of slack. For research, these results support the importance of further investigating MSs as tools for competitive advantage and corporate sustainability in a world where resources are scarce, and efficiency is almost mandatory to ensure resilience.

The main limitation of this paper is related to the measurement of variables, as it is done based on the data of an existing database. For this reason, factors that are discussed in this article such the integration of MSs, the ambidextrous capacity of firms implementing multiple MSs, or the reasons for decertification could not be assessed. Moreover, including more practices that could be related to these MSs, such as the use of other types of slack resources (i.e., observed and operational slack), could improve the understanding of the studied relationships. Future research will focus on overcoming these limitations.

CRediT authorship contribution statement

Alfonso Hernandez-Vivanco: Conceptualization, Methodology, Software, Formal analysis, Investigation, Data curation, Writing – original draft, Visualization, Project administration, Funding acquisition. **Merce Bernardo:** Conceptualization, Validation, Resources, Writing – review & editing, Supervision, Funding acquisition.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

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Appendix

Table A1
Description of variables

Variable	Description
EPI-design	Does the company report on specific products that are designed for reuse, recycling, or reduction of environmental impacts? Does the company report on at least one product line or service that is designed to have positive effects on the environment or which is environmentally labelled and marketed?
EPI-use	Does the company report about product features and applications or services that will promote responsible, efficient, cost- effective, and environmentally preferable use? Does the company describe initiatives in place to reduce the energy footprint of its products during their use? Does the company develop new products that are marketed as reducing noise emissions?
ISO 9000	Does the company claim to have an ISO 9000 certification or any industry specific certification (QS-9000-automotive, TL 9000-telecommunications, AS9100-aerospace, ISO/TS 16949-automotive, etc.)? - consider if the company claims to have ISO 9000 certification for one site or more - consider any industry-specific quality management system such as QS 9000-automotive, TL 9000-telecommunications, AS 9100-aerospace, ISO/TS 16949-automotive - validity: ISO certification information is considered for 3 years
ISO 14000	

(*continued on next page*)

Table A1 (*continued*)

Variable	Description
	Does the company claim to have an ISO 14000 or EMS certification? - any of the individual site that has the ISO-14001 certification is qualified information - merely stating adherence to ISO 14000 or following ISO 14000 policies does not qualify, certification is required Other EMSs different of ISO 14000 were excluded
OHSAS 18001	Does the company have health and safety management systems in place like the OHSAS 18001 (Occupational Health & Safety Management System)? - consider if the company claims to have OHSAS 18001 or any internal management system for one site or more - include environment, health, and safety (EHS) management system - consider if companies complying with OHSA (Occupational Health and Safety Act) Includes ISO 45000
Slack	Total current assets/total current liabilities (log)
Stakeholder engagement score	Does the company explain how it engages with its stakeholders? -Information on how the company is engaging with its stakeholders, how it is involving the stakeholders in its decision-making process; what procedures are in place for engagement - Focus on having established two-way communication between the company and its various stakeholders
Product Responsibility score	It reflects a company's capacity to produce quality goods and services integrating the customer's health and safety, integrity and data privacy.
Environmental R&D	Does the company invest in R&D on new environmentally friendly products or services that will limit the amount of emissions and resources needed during product use?
Size	Number of employees (log)

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