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Internalization of Management Systems and Eco-Product Innovation: The More the Better?

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ABSTRACT

Environmental challenges demand urgent and strategic responses from firms. Eco-product innovation (EPI) is a key approach to reducing environmental impact while preserving competitiveness. This research analyses the relationship between EPI and the internalization of management system (MS) certifications, focusing on ISO 9001, ISO 14001, and ISO 45001, whether adopted individually or in combination. Using secondary panel data from 2769 firms in Europe and Asia from 2006-2019, a panel logit analysis was conducted, supported by multiple robustness checks. The results reveal that only ISO 14001, individually and in combination, is positively related to EPI, while ISO 9001 and ISO 45001 show no direct effect unless combined with ISO 14001. Furthermore, certification duration shows an inverted U-shaped relationship with EPI, highlighting the dynamic nature of EPI capability development linked to the internalization of MSs and the risk of erosion over time. Grounded in the dynamic resource-based view, this paper emphasizes the dynamic nature of capabilities associated with the internalization of MSs and its consequences for EPI and as such has several implications for academia and practitioners.

1 | Introduction

The world is facing growing environmental challenges, including climate change, pollution, and resource depletion (United Nations Environment Programme 2021), which business strategies can no longer afford to ignore (Bansal et al. 2025). In response, eco-product innovation (EPI) has gained increasing attention as a strategy to reduce environmental impact while maintaining competitiveness (Qiu et al. 2020). A related perspective, and one which also interconnects with EPI, is the implementation of management system (MS) standards (Hernandez-Vivanco and Bernardo 2022; Papagiannakis et al. 2019; Valero-Gil et al. 2023). These include ISO 9001 for quality (QMS), ISO 14001 for environmental impact (EMS), and ISO 45001 for occupational health and safety management systems (OHSMS), which are among the most widely certified standards worldwide (ISO 2025).

Traditionally, the literature on eco-innovation has used the implementation of EMSs to measure the internal resources and capabilities driving eco-innovation (del Río et al. 2016). This is because EMSs enable the systematic identification and management of environmental aspects, including pollution prevention, environmental performance, and compliance with applicable laws (Fonseca et al. 2022). This method for operationalizing firms' eco-innovation capabilities assumes that firms integrate the practices embedded in the MS (e.g., Tarí et al. 2019) into their daily activities as a catalyst for change, what is termed the internalization of MSs (Naveh and Marcus 2005). There seems to be a growing consensus that EMSs drive environmental benefits, stemming from investments (Testa, Boiral, and Iraldo 2018; Testa, Iraldo, and Daddi 2018; Iatridis and Kesidou 2018; Demirel and Kesidou 2019), including eco-innovation, but only when substantially internalized rather than implemented in a superficial or symbolic manner (Hernandez-Vivanco et al. 2018;

Daddi et al. 2021; Papagiannakis et al. 2019). Therefore, the internalization of EMSs, rather than their mere implementation, is what truly drives the capability to produce eco-innovation (Daddi et al. 2021; del Río et al. 2016; Iatridis and Kesidou 2018).

Recent literature suggests that EMSs can indeed promote EPI by leveraging the available internal resources (Hernandez-Vivanco and Bernardo 2022) or by internalizing them through stakeholder engagement (Testa, Boiral, and Iraldo 2018; Papagiannakis et al. 2019). However, other studies suggest that EMSs are more related to process innovation than to EPI (Wagner 2008), while others find that they hinder eco-innovation by introducing organizational rigidities (Valero-Gil et al. 2023). This ongoing debate is mirrored in the literature relating QMSs (and other standards) to innovation in general (Blind et al. 2023; Clougherty and Grajek 2023; El Manzani et al. 2024) and to EPI in particular (Hernandez-Vivanco and Bernardo 2022; Papagiannakis et al. 2019). Notably, the current discussion often overlooks the fact that capabilities change over time (Helfat and Peteraf 2003), and those related to the internalization of MSs are no exception (Heras-Saizarbitoria and Boiral 2015). The lack of longitudinal research in this field (Heras-Saizarbitoria and Boiral 2013), combined with the possibility that internalization capabilities may eventually erode (Boiral 2011; Heras-Saizarbitoria and Boiral 2015), may explain the lack of consensus observed in the literature (Helfat 2000).

Furthermore, several studies suggest that it is not only EMSs that drive EPI, but also joint experiences with other MSs, particularly QMSs (Papagiannakis et al. 2019) and OHSMSs (Hernandez-Vivanco et al. 2018; Hernandez-Vivanco and Bernardo 2022). This is important because there is an increasing trend toward multiple management systems (MMSs) in industry as reported in the literature (Bernardo et al. 2009; Hernandez-Vivanco and Bernardo 2022, 2023). Firms that adopt multiple certifications typically do not implement these standards in a completely independent manner, but instead leverage the synergies among them to develop a more effective integrated MS (Bernardo et al. 2009). This makes the adoption of MMSs a key strategy for both sustainability and profitability (Ronalter and Bernardo 2023; Ronalter et al. 2024; Hernandez-Vivanco et al. 2019). The adoption of MMSs inherently promotes innovation within organizations, mainly because of the organizational adjustments that require employee alignment and adaptation, taking into account both internal processes and contextual influences such as cultural and rational perspectives of different stakeholders involved in their integration (Bernardo 2014; Chountalas and Lagodimos 2024). Although further research is needed (Wang and Liu 2023), MMSs do appear to play a role in fostering process and product innovation (Hernandez-Vivanco et al. 2016, 2018), including EPI (Hernandez-Vivanco and Bernardo 2022). Similar to the case of the implementation of individual MSs, however, the literature on the relationship between MMSs and EPI assumes constant (rather than dynamic) internalization of the corresponding MSs.

To address these gaps, this study aims to research into the dynamic relationship between the internalization of MSs and EPI. The former includes the adoption of both individual MSs and MMSs. Given the long history and practical experience of firms worldwide with ISO MSs (Boiral 2011), we focus on ISO 9001, ISO 14001, and ISO 45001 (OHSAS 18001 until 2018) (ISO 2025). Grounded in the dynamic resource-based view (DRBV) (Helfat and Peteraf 2003) and based on a panel dataset of 2769 Asian and European firms from 2006 to 2019, results suggest that only ISO 14001 promotes EPI, even more when implemented in combination. Furthermore, the capabilities associated with the internalization of MSs are positively related to EPI for nearly a decade, after which these capabilities begin to erode (following the capability life cycle), thus hindering EPI.

This study makes three key contributions to the literature. First, it advances the ongoing debate on the relationship between MSs/MMSs and innovation (Blind et al. 2023; Manders et al. 2016; Wang and Liu 2023; Valero-Gil et al. 2023), particularly EPI (Hernandez-Vivanco and Bernardo 2022; Papagiannakis et al. 2019), by showing that ISO 14001, whether implemented individually or jointly, can promote EPI, while ISO 9001 and ISO 45001 contribute to EPI only when jointly implemented with ISO 14001. This finding extends existing discussions by highlighting the importance of specific MS combinations for sustainability performance (Helfat et al. 2024). Second, the study applies the capability lifecycle (CLC) concept from DRBV to the internalization of MSs, showing that these are dynamic capabilities linked to intangible resources (Helfat and Peteraf 2003). Third, it introduces a methodological contribution by offering an objective, longitudinal measure of MS internalization, using secondary data (Heras-Saizarbitoria and Boiral 2013).

The paper is structured as follows: Section 2 presents the theoretical framework, including the development of the hypotheses. Section 3 describes the methodology, followed by the results in Section 4. Finally, Section 5 contains the discussion and conclusions.

2 | Literature Review

2.1 | The Dynamic Resource-Based View

The dynamic resource-based view (DRBV) extends the traditional resource-based view (RBV) by explicitly incorporating the role of change over time in the development and evolution of firm capabilities (Helfat and Peteraf 2003). While the classical RBV emphasizes the importance of valuable, rare, inimitable, and nonsubstitutable resources in sustaining competitive advantage (Barney 1991), it often assumes a relatively static environment. In contrast, the DRBV acknowledges that firms operate in dynamic contexts where maintaining competitiveness requires the ability to adapt, transform, and renew capabilities.

Central to the DRBV is the notion that capabilities evolve, and this evolution significantly shapes performance trajectories. Helfat (2000) highlights how capabilities do not simply appear fully formed, but rather emerge, develop, and adapt over time, influenced by factors such as learning, aspiration levels, and managerial cognition. Some firms succeed in developing capabilities that match or even shape market demands, while others struggle to adapt, leading to diverging performance outcomes. Historical paths and cumulative learning experiences are thus essential for understanding why some firms maintain or enhance competitive advantage while others decline.

Helfat and Peteraf (2003) elaborated on this view by introducing the CLC. Similar to a product lifecycle, the CLC conceptualizes capabilities as passing through stages: founding, development, and maturity. These are followed by potential branching paths, namely, (i) replication, which keeps capabilities stable, (ii) renewal (refreshing or updating an existing capability that has become less effective), redeployment (applying an existing capability in a different context or area) or recombination (integrating existing capabilities to create a new one or improve performance), which expand capabilities, or (iii) retrenchment, which lead to a decline or erosion of capabilities. These stages reflect how capabilities are not static assets, but evolving processes that can change in form and function in response to internal and external selection pressures. Importantly, this model encompasses both operational and dynamic capabilities, with the latter enabling firms to reconfigure existing resources and routines in response to shifting environments.

2.2 | The Implementation of MSs and EPI

The growth of global supply chains has increased emphasis on the adoption of voluntary MSs as a regulatory mechanism to address stakeholder concerns (Büthe and Mattli 2011). These MSs can be audited and certified by independent third-party bodies that assess whether a system complies with international standards and achieves the intended results (Fonseca et al. 2022). As voluntary certifications, MSs are designed to strengthen firms' internal practices and mitigate organizational shortcomings (Boiral 2011). This approach makes firms more innovative (Daddi et al. 2021; Ullah 2022), thus encouraging the pursuit of EPI (Hernandez-Vivanco and Bernardo 2022; Papagiannakis et al. 2019). From the DRBV perspective, MSs could support EPI by dynamically shaping firms' internal capabilities through development, renewal, redeployment, and recombination processes (Helfat and Peteraf 2003) as it is discussed next.

Eco-innovation is generally defined as the development of products that minimize environmental impacts across their life cycle, involving relevant stakeholders throughout the innovation process (EIO (Eco-Innovation Observatory) 2010; Horbach et al. 2012). Within this context, ISO 14001 is a key driver of EPI as it promotes environmental awareness and stakeholder engagement (Hernandez-Vivanco and Bernardo 2022; Hojnik and Ruzzier 2016). By requiring firms to integrate environmental considerations into organizational routines, ISO 14001 facilitates the renewal of existing capabilities, updating traditional operational practices with an environmental focus and aligning strategies with sustainability goals (Iatridis et al. 2016; Daddi et al. 2021; Torres-Rubira et al. 2023).

ISO 9001 can also support innovation. Its customer focus principle renews market-sensing capabilities by promoting a better understanding of current and future customer needs, which helps guide innovation efforts and align strategy with technological capabilities (Martínez-Costa and Martínez-Lorente 2008; Perdomo-Ortiz et al. 2006). Its leadership principle promotes recombination of capabilities by fostering a shared vision that integrates innovation goals, thus stimulating a culture oriented toward both incremental and radical change (Perdomo-Ortiz et al. 2006). Process management, grounded in the Plan-Do-Check-Act cycle, supports the redeployment of established routines toward environmental improvements, although its emphasis on standardization and repetition tends to favor incremental over radical innovation (Benner and Tushman 2002). ISO 9001 is more than a compliance tool; it serves as a dynamic capability that enables firms to adapt to changing environments, thus fostering technological, nontechnological, and green innovations (El Manzani et al. 2024; Li et al. 2018), potentially including EPI (Manders et al. 2016; García-Fernández et al. 2022; Zeng et al. 2017).

ISO 45001 (formerly OHSAS 18001) addresses occupational hazards, health, and safety in the workplace and legal compliance (Morgado et al. 2019). Although its link with EPI is less obvious (Hernandez-Vivanco and Bernardo 2022), it can still support innovation and sustainability by means of knowledge management tools that are relevant to this end (Donnelly and Wickham 2019). By fostering systems thinking and functioning as a platform for knowledge exchange and management, ISO 45001 helps develop systems-related capabilities (Gressgård 2014; Karanikas et al. 2022) that can indirectly support EPI through sustainability-oriented process improvements, especially when implemented alongside ISO 14001 (Hernandez-Vivanco et al. 2018).

Moreover, ISO 14001 supports the redeployment of managerial and operational competencies toward environmental performance and compliance, forming the basis for EPI when implemented alone or in combination with other MSs (Hernandez-Vivanco and Bernardo 2022). For example, firms often leverage prior experience in quality or operational management and apply it to environmental monitoring, risk management, or cleaner production initiatives (Castka and Prajogo 2013; Hernandez-Vivanco et al. 2018). However, while these standards are widely associated with internal and process-related improvements (Bothongo and Kinyar 2025; Hojnik and Ruzzier 2016), their contribution to product-level innovation remains debated (Blind et al. 2023; Dangelico 2016). Some studies argue that ISO 14001 may constrain EPI (Valero-Gil et al. 2023), whereas others highlight that its effectiveness depends on resource availability (Demirel and Kesidou 2019) and complementarity with other frameworks such as ISO 9001 (Cassânego et al. 2025; Hernandez-Vivanco and Bernardo 2022; Papagiannakis et al. 2019; Tayo Tene et al. 2021) or OHSAS 18001 (Hernandez-Vivanco and Bernardo 2022).

This complementarity allows firms to recombine capabilities across systems. Customer engagement fostered by ISO 9001 (Cuerva et al. 2014), employee involvement promoted by OHSAS 18001 (Huang and Chen 2022), and the environmental awareness instilled by ISO 14001 create opportunities for firms to integrate diverse stakeholder knowledge and perspectives (Tarí et al. 2019). Such recombination enhances firms' ability to generate eco-innovative solutions that meet both environmental and market demands (Papagiannakis et al. 2019). Furthermore, MMS adoption expands stakeholder engagement and enables firms to become more sustainability-oriented, especially when integrated (Nunhes et al. 2022)

In line with the DRBV, ISO 14001, ISO 9001, and ISO 45001 thus contribute to capability development by enabling the renewal of existing routines, the redeployment of competencies toward environmental objectives, and the recombination of knowledge to support EPI. By integrating complementary approaches, these MSs support innovation (Bernardo 2014; Hernandez-Vivanco et al. 2016) and, more specifically, sustainable innovation (Hernandez-Vivanco et al. 2018) and EPI (Hernandez-Vivanco and Bernardo 2022; Papagiannakis et al. 2019). Thus, hypothesis 1 (H1) is posed:

H1. *Firms holding ISO* 9001 *ISO* 14001 *and/or ISO* 45001 *in their certification strategies, whether individually or in combination, are more likely to develop EPI compared to their noncertified peers.*

2.3 | The Relationship Between the Internalization of MSs and EPI

The roadmap for successful implementation of ISO standards proposed by Boiral (2011) is closely linked to the CLC model (Helfat and Peteraf 2003). It consists of the following four stages: (1) certification decision, (2) system design, (3) implementation, and (4) follow-up. We build on this roadmap by tracking the evolution of MSs' internalization in relation to EPI capabilities. When certification decisions are driven by intrinsic motivations, such as improving sustainability or quality performance, rather than commercial or symbolic motives (Iatridis and Kesidou 2018), internalization begins to form strategically aligned capabilities that can drive EPI.

The implementation phase corresponds to the process of "learning by using," which develops innovation capabilities (Bourke and Roper 2017). At this stage, managerial commitment and employee engagement, both rational and emotional, translate certification into meaningful organizational change through resource allocation (Boiral 2011). At this point, the capabilities may evolve through recombination (integrating different MMSs practices; Bernardo et al. 2009), or renewal (refining practices through feedback and learning; Bourke and Roper 2017), satisfying the needs of various stakeholders (Castka and Prajogo 2013; Papagiannakis et al. 2019; Iatridis and Kesidou 2018). When these ideals are embedded into daily practices (i.e., MSs become more internalized), employees' motivations (Ataseven et al. 2014; Escrig-Tena et al. 2019; Gianni and Gotzamani 2024; Tarí et al. 2019), as well as the formalization of tacit knowledge (Boiral 2002, 2011), reinforce the capability's institutionalization and strengthen the potential for generating EPI. During this stage, capabilities are expected to develop over time. For example, Fonseca (2015) suggests that the longer an organization holds ISO 9001 certification, the better its EFQM (European Foundation for Quality Management) evaluation and recognition.

When capabilities derived from MSs are fully embedded and extended across the organization, including those related to EPI, this reflects a mature stage in the CLC associated with the internalization of MSs (Heras-Saizarbitoria 2011). This maturity is particularly beneficial when firms attach other standards, related or unrelated, to address stakeholder demands, thus fostering internalization (Allur et al. 2014; Testa, Boiral, and Iraldo 2018; Testa, Iraldo, and Daddi 2018) and supporting innovation outcomes (Papagiannakis et al. 2019). Empirical evidence shows that the integration of MMSs fosters the adoption of cleaner technologies and environmental practices, although outcomes vary depending on the degree of internalization (Tarí et al. 2021). For example, EPI often emerges only in more advanced stages of MMSs internalization (Hernandez-Vivanco et al. 2018)

Finally, the follow-up stage represents a critical juncture in the postmaturity trajectory of capabilities (Helfat and Peteraf 2003). Firms that commit to continuous improvement may maintain the innovation benefits associated with MSs by adapting capabilities over time (Bourke and Roper 2017) and preserving strategic value (Darnall and Edwards 2006). However, lack of follow-up can signal declining commitment, leading to capability erosion (Boiral 2011). At this stage, capabilities may not align with strategic goals, or are maintained only symbolically, thus contributing little to innovation and eventually eroding EPI capabilities. For instance, more innovative firms may encounter more barriers than benefits derived from the certification and eventually decertify (Clougherty and Grajek 2023). In other cases, certifications are retained but pose significant obstacles for eco-innovation (Valero-Gil et al. 2023).

Decertification process is rarely sudden, and some firms retain certifications for external reasons, such as corporate image (Cândido and Ferreira 2023). In such cases, certification (an intangible resource) is still held by the firm but is no longer internalized. This "symbolic certification" (Iatridis et al. 2016; Iatridis and Kesidou 2018; Testa, Boiral, and Iraldo 2018) is what the broader strategic management literature calls "resource idling" (Rahmandad and Repenning 2016) and is a major cause for the erosion of EPI capabilities (Helfat and Peteraf 2003). It has been linked to "organizational forgetting" (in this case of the value of the MSs) (Rahmandad 2012) and the shift from capability development to mere compliance with external pressures (Iatridis and Kesidou 2018).

Therefore, the relationship between certification and EPI should not be expected to grow linearly. Instead, an inverted U-shape is proposed, whereby certifications initially contribute to EPI capability development, stabilize at a high level of EPI during maturity, and decline as capabilities erode. Thus, H2 is proposed:

H2. *The length of time a firm holds at least one certification has an inverted U-shaped relationship with EPI.*

Figure 1 shows the proposed model. Using the DRBV as the analytical lens, H1 tests how the implementation of MSs promotes EPI capabilities. H2 takes into account the CLC of these capabilities, including the stages of capability development after certification, maturity, certification idling and eventual erosion.

3 | Methodology

3.1 | The Sample

This study uses secondary panel data from the Refinitiv Eikon database, which gathers information from trusted sources in more than 30,000 firms across over 180 countries. Eikon applies a consistent methodology to obtain and process data from diverse sources, including annual reports and trusted news outlets, among others. Of special interest are EPI-related variables and certifications under ISO 9001, ISO 14001, and

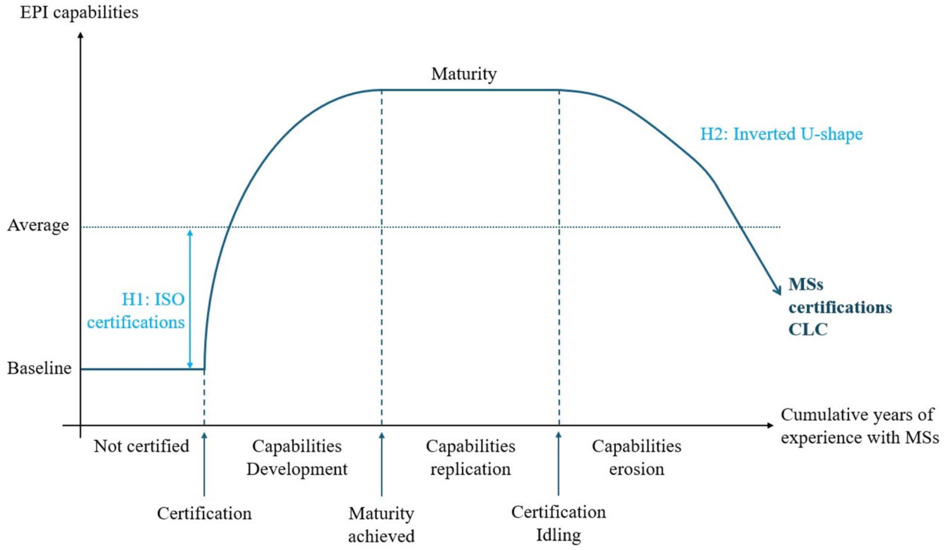

FIGURE 1 | Proposed model linking MSs internalization and EPI capabilities grounded in the DRBV. *Source:* own elaboration.

TABLE 1 | Summary statistics (continuous variables).

Continuous variables	Mean	Median	SD	SE (mean)	Min	Max
EPI	0.574	1	0.495	0.004	0	1
EPI design	0.495	0	0.500	0.004	0	1
EPI use	0.562	1	0.496	0.004	0	1
Years certified	4.565	4	4.137	0.030	0	14
$\text{Slack}_{t\text{-}1}$ (log)	0.355	0.329	0.645	0.005	−5.052	4.497
$\text{Stakeholder engagement}_{t\text{-}1}$	35.578	0	37.405	0.268	0	98.571
$\text{Product responsibility}_{t\text{-}1}$	48.993	51.639	33.628	0.241	0	99.870
Economic openness	87.11	59.70	87.86	0.629	24.39	442.62
Size (log)	9.220	9.306	1.704	0.012	0.693	14.070

Note: N = 19,502; 2769 firms. *Source:* own elaboration.

ISO 45001 (OHSAS 18001 until 2018). The initial panel dataset consisted of 25,470 observations. However, some observations with missing information were excluded, and some variables were lagged in the model specification (see Sections 3.2 and 3.3). Outliers were also removed, and data were validated to ensure stability across sectors, regions, and time periods. Though initially considered, year 2020 was eventually dropped due to highly irregular behavior, likely reflecting pandemic-related shocks. Thus, the final dataset is an unbalanced panel of 19,502 observations from 2769 different firms for the 2006–2019 period. These companies belong to 11 different sectors in Asia and Europe.

3.2 | Measurement of Variables

3.2.1 | Dependent Variable

EPI measurement was constructed using the five items included in the "product innovation" section of Eikon, which tracks the design and use of products with environmental features. As all original variables were binary ("Yes/No"), EPI was coded as 1 when affirmative and 0 otherwise (Hernandez-Vivanco and Bernardo 2022). Further details are provided in Table A1 in the Appendix.

Table 1 presents the descriptive statistics of the continuous variables. On average, 57.36% of the cases engaged in EPI over the period. Interestingly, 1071 firms in the sample never reported EPI, while only 280 did so for every year covered in the sample. This seems to challenge the median value of 1. However, given the unbalanced nature of the panel, it is also true that 980 firms performed EPI in all the years for which they reported data.

3.2.2 | Independent Variables

The specific certifications held by a firm/year denote the first explanatory variable to test the internalization hypotheses. Considering the three standards studied in this research (ISO 9001, ISO 14001, and ISO 45001), seven possible combinations, plus not holding any certification, are captured in the "Certifications" categorical variable used to test H1 (Hernandez-Vivanco and Bernardo 2022). In the final sample, 78.39% of the companies were certified at least once over the period considered. Among these, 83% were certified with ISO 14001 at least once (either alone or combined), while only 73.68% and 78.47% held ISO 9001 and ISO 45001, respectively, at some point.

As shown in Table 2, the most frequent combination in the sample is triple certification (32.83%), which more than doubles any of the other options. It also presents the highest propensity of EPI (75.56%). Roughly, any other combination containing ISO 14001, including the single certification, has EPI levels in a similar but slightly lower range, while firms with no certification exhibit the lowest EPI levels (28.78%).

To test H2, a proxy measuring internalization called "Years certified" was constructed, based on the assumption that longer certification experience equates to greater internalization of practices, as compared to adopters with no or scarce experience managing MSs certifications (Bernardo et al. 2018). This variable reflects the cumulative number of years that a given firm has held at least one certification. Only consecutive years are considered, so if a firm decertifies or information is missing for a given period, the variable resets. Values range from 0 (not certified) up to 14, being 1 the first year of certification. Table 1 shows that the sampled companies were certified for an average of 4.56 consecutive years.

3.2.3 | Control Variables

Eight control variables were included. Slack (of financial) resources are measured as the ratio of current assets to current liabilities at a specific moment. Values higher than 1 indicate positive short-term excess working capital that can be redeployed into new projects in subsequent periods, such as EPI (Hernandez-Vivanco and Bernardo 2022; Papagiannakis et al. 2019). The lagged value of the slack was used, and the logarithm was applied to account for the skewed distribution of the variable (e.g., Berrone et al. 2013). In logarithmic terms, a positive value would imply positive working capital. Thus, Table 1 confirms the presence of resource slack among the firms in the sample.

Stakeholder Engagement is another important factor in EPI performance (Papagiannakis et al. 2019), reflecting effective communication between the firm and its stakeholders and involvement of the latter in decision-making. This was measured by directly taking the 0–100 Eikon scores. The same procedure was used to gauge Product Responsibility, which measures a firm's capacity to deliver high-quality offerings for its customers (Papagiannakis et al. 2019).

Environmental R&D is a dummy variable that takes the value of 1 if the firm invested in R&D, and 0 otherwise (Leyva-de la Hiz et al. 2019). Table 2 shows how more than 91% of firms investing in environmental R&D performed EPI, as opposed to only 53.7% of the firms that made no such investments, suggesting a direct impact. Size is controlled by the logarithm of the number of employees (Hernandez-Vivanco and Bernardo 2022; Daddi et al. 2021; Papagiannakis et al. 2019). Economic Openness, measured as the sum of imports and exports as a percentage of GDP (Costantini et al. 2023), was included as a country-level variable, controlling for contextual factors. Sector dummies are based on the Global Industry Classification Standard (GICS) and, finally, region dummies control for the firm's home region (Europe or Asia), accounting for broader, context-specific features. See Table 3 for the correlations.

3.3 | Model Specification

Because the dependent EPI variable is binary, a panel logit approach was used. Under the assumption of non-constant variance in the errors, models were based on heteroskedasticity-robust standard errors (Wooldridge 2010). Population-averaged logit estimations were chosen because they provide a more reliable approximation of the truth, as compared to other methods, as firms' EPI outcomes may be correlated within the same sectors and/or regions, violating independence assumptions in generic regression specifications (Hubbard et al. 2010). Accordingly, the estimated effects are based on average firm behavior. Thus, following the specialized literature (e.g., Hubbard et al. 2010), the panel population-averaged logit model is specified as follows:

$$logitP\left(Y_{it} = 1 | X_{it}\right) = \alpha + \beta X_{it}, \quad (1)$$

where Y denotes EPI; $i = 1, \ldots, N$ and $t = 1, \ldots, T$ represent, respectively, firms and time periods; X_{it} is the set of independent and control variables; $logitP\left(Y_{it} = 1 | X_{it}\right)$ is the logistic function for the conditional probability of having a positive outcome $(Y_{it} = 1)$ given a set of X_{it} parameters; α is a fixed constant and β is a vector of the estimated coefficients of the logit regression.

3.3.1 | Methods for Analysis of Logit Models

Coefficients obtained directly from logit regressions are not marginal effects and therefore lack a probability interpretation due to their nonlinear nature. Further analysis should be performed to interpret their results (Hubbard et al. 2010; Uberti 2022). In this paper, such an analysis was carried out using the statistical software Stata 17.0., as suggested by Uberti (2022).

The direct effects of certification internalization on EPI, to test H1, were measured based on marginal effects, which were calculated as the change in the probability of a positive outcome given a change in the variable of interest x_i (i.e., $\partial P / \partial xi$) using the *dydx* method for all variables. For continuous variables, these coefficients represent the impact on the probability of EPI [i.e., $P\left(Y_{it} = 1 \vee x_i, X_i\right)$] of a "marginal" (infinitesimally small) change in x_i (Uberti 2022, 61–62). For categorical variables, for a given level m, these coefficients represent the discrete change, on average, from the probability of EPI at the reference level r [i.e., $P\left(Y_{it} = 1 | x_i = m, X_i\right) - P\left(Y_{it} = 1 \vee x_i = r, X_i\right)$]. This is also known as the contrast of margins (Uberti 2022, 66–67). Finally, because the quadratic term required to test

TABLE 2 | EPI distribution per categorical variable.

Categorical variables	Code	Freq.	Percent	Cum.	EPI
Overall					0.574
Certifications					
No	0 (ref.)	4949	25.38	25.38	0.288
ISO9001	1	788	4.04	29.42	0.412
ISO14001	2	1808	9.27	38.69	0.637
ISO45001	3	1027	5.27	43.95	0.413
ISO9001 + ISO14001	4	2237	11.47	55.43	0.709
ISO9001 + ISO45001	5	289	1.48	56.91	0.474
ISO14001 + ISO45001	6	2002	10.27	67.17	0.651
Triple	7	6402	32.83	100	0.756
Environmental R&D$_{t-1}$					
No	0 (ref.)	17,594	90.22	90.22	0.537
Yes	1	1908	9.78	100	0.914
Region					
Asia	0 (ref.)	9792	50.21	50.21	0.548
Europe	1	9710	49.79	100	0.600
Sector					
Communication services	0 (ref.)	1483	7.60	7.60	0.457
Consumer discretionary	1	2828	14.50	22.11	0.555
Consumer staples	2	1555	7.97	30.08	0.435
Energy	3	1044	5.35	35.43	0.451
Financial	4	564	2.89	38.32	0.261
Health care	5	1264	6.48	44.81	0.275
Industrial	6	4651	23.85	68.65	0.707
Information technology	7	1586	8.13	76.79	0.683
Materials	8	2268	11.63	88.42	0.680
Real estate	9	1232	6.32	94.73	0.506
Utilities	10	1027	5.27	100	0.739
Year					
2007	1	893	4.58	4.58	0.386
2008	2	957	4.91	9.49	0.546
2009	3	1062	5.45	14.93	0.610
2010	4	1186	6.08	21.01	0.623
2011	5	1408	7.22	28.23	0.613
2012	6	1475	7.56	35.80	0.610
2013	7	1426	7.31	43.11	0.601
2014	8	1519	7.79	50.90	0.587
2015	9	1612	8.27	59.16	0.573

(Continues)

TABLE 2 | (Continued)

Categorical variables	Code	Freq.	Percent	Cum.	EPI
2016	10	1646	8.44	67.60	0.574
2017	11	1721	8.82	76.43	0.574
2018	12	2062	10.57	87.00	0.554
2019	13	2535	13.00	100	0.561

Note: $N = 19{,}502$; 2769 firms. *Source:* own elaboration.

H2 is essentially an interaction term, a plot was constructed to show the change in the probability of EPI for each additional year of certification ("Years certified") based on a 95% confidence (Uberti 2022, 70–75).

4 | Results

This section presents the main findings for H1 and H2. Before testing them, several diagnostic checks were performed to assess the key model assumptions (Stoltzfus 2011; Hosmer et al. 2013). These addressed the independence of observations (using clustered robust standard errors), the linearity of the model for continuous predictors (by adding interaction terms between continuous predictors and their logs, none being significant), the absence of multicollinearity (correlation matrix in Table 3 and all VIF values ranging between 1.07 and 3.80, thus below the recommended maximum of 5), and the absence of influential outliers. Only 37 observations were considered outliers upon squared deviance residuals and Pearson residuals from the logit estimations and these were removed from the final sample.

Table 4 presents the results for the estimation of the logit models from equation (1), with Models 1 to 4 displaying the coefficients for the predictor variables. Model 1 includes only control variables. Model 2 adds the direct effect of different combinations of certifications. Model 3 introduces the effect of the number of years certified. Finally, Model 4 is the full model, including the squared number of years certified, monitoring for quadratic effects over time. Models 5 to 8 on the right-hand side of Table 4 present the corresponding marginal effects for the previous models.

The results clearly show that firms holding any combination of certifications including ISO 14001 are significantly more likely to perform EPI. This standard alone increases the probability of performing EPI by 9.1% (see Model 8), as compared to non-certified firms. However, when combined with other certifications, that probability rises further: 11.9% if combined with ISO 9001, 11.2% with ISO 45001, and 12.4% in the case of triple certification.

Contrarily, holding ISO 9001, ISO 45001, or both in tandem (excluding ISO 14001) does not affect the probability of performing EPI, as compared to firms not holding any certification. Overall, H1 is partially supported since ISO 14001 (alone or in combination) acts as the main driver of EPI performance, whereas the other certifications have no impact.

The cumulative number of years certified has also a positive and significant effect: 1.1% for every additional year holding a certification (see Model 8). However, to test for the inverted U-shape predicted by H2, the difference in the probability of EPI for each additional year of certification is plotted

Figure 2, on the left, illustrates the quadratic effect predicted by H2. It can be observed how the variation in the expected probability of EPI consistently increases, on average, up to about the ninth year (Difference in P (EPI): 0.5948), and then starts to decrease. Furthermore, marginal effects shown on the right confirm that this increase in probability is significantly positive up to the seventh year (capability development stage), then remains stable until the 14th year (mature stage), followed by a significant decrease (decline stage). This supports H2, showing that a higher number of consecutive years holding a certification has an inverted U-shape relationship with the probability of performing EPI.

As for control variables, lagged financial slack has no effect. The other variables have a positive and significant impact: higher EPI equates to greater stakeholder involvement, more environmental R&D, stronger product responsibility, and superior economic openness and firm size. Region also matters, as European firms are 5.7% more likely to report EPI than their Asian peers.

4.1 | Robustness Checks

A series of robustness checks was conducted to test the reliability of the main findings. First, while the logit model is more extensively used in the revised literature (e.g., Hosmer et al. 2013; Uberti 2022), and both the logit and probit usually lead to similar conclusions (e.g., del Río et al. 2016; Breen et al. 2025), the main models were replicated based on probit analyses. As expected, this method yielded similar conclusions. Second, given the unbalanced nature of the dataset, the original models were re-estimated using a refined subsample of firms reporting at least 10 consecutive years of data (13,112 observations, from 1047 firms). Again, the original conclusions held.

Third, an alternative measure of EPI was constructed by summing the number of EPI items reported by firms, ranging from 0 to 5 (following Papagiannakis et al. 2019). A value of 0 would indicate that the firm reported not to carry out any of the EPI features in the survey; 5 would imply all of them. This measure is based on the implicit assumption that a higher number of implemented features improves performance, despite making no account for actual depth of implementation. Nevertheless, ordinary least squares (OLS) estimations produced similar results and conclusions to the original model.

TABLE 3 | Correlation coefficients.

Variable	1	2	3	4	5	6	7	8	9	10	11	12
1. EPI	1											
2. Certifications	0.353	1										
3. Years certified	0.352	0.617	1									
4. Slack$_{t\text{-}1}$ (log)	−0.066	−0.010^{ns}	0.008^{ns}	1								
5. Stakeholder engagement$_{t\text{-}1}$	0.261	0.349	0.296	−0.110	1							
6. Environmental R&D$_{t\text{-}1}$	0.226	0.168	0.214	0.018**	0.080	1						
7. Product responsibility$_{t\text{-}1}$	0.331	0.457	0.426	−0.074	0.351	0.161	1					
8. Economic openness	−0.106	−0.036	−0.082	0.007^{ns}	0.021**	−0.148	−0.099	1				
9. Size (log)	0.257	0.309	0.278	−0.159	0.230	0.162	0.264	−0.053	1			
10. Region	0.053	0.071	0.054	−0.130	0.096	−0.183	0.114	−0.010^{ns}	−0.096	1		
11. Sector	0.150	0.171	0.101	0.007^{ns}	0.040	0.094	−0.035	0.043	−0.107	−0.020	1	
12. Year	0.008^{ns}	0.098	0.342	0.019	0.199	−0.068	0.177	0.030	−0.052	−0.025	−0.001^{ns}	1

Note: No asterisk $p < 0.01$, ** $p < 0.05$, ns > 0.1. $N = 19{,}502$; 2769 firms. *Source:* own elaboration.

Fourth, because ISO standards undergo periodic revisions, potentially influencing the adoption of MSs and subsequent innovation outcomes (Fonseca et al. 2023; Manders et al. 2016), the panel logit models were re-estimated while controlling for ISO standard versions available in each year. Still, accounting for the potential impacts of periodic revisions did not affect the main findings.

Finally, two alternative measures of EPI were built: EPI-design and EPI-use (Hernandez-Vivanco and Bernardo 2022) to account for potential differences in the design and use stages of EPI (Demirel and Kesidou 2011). In the original set of 5 EPI-related variables, three of them refer to design features and two of them to use stages. This split would differentiate between environmental considerations that typify early-stage innovation (EPI-design) and more advanced stages when the focus tends to be on the end-of-pipe innovation (EPI-use). In both cases, the decreasing effect associated with the quadratic form seen in the main model is again observed, but in neither case is the decrease in the decline stage significant.

Since all the robustness checks lead to the same conclusions, the specific estimations are not included in this manuscript but are available upon request.

5 | Discussion and Conclusions

This study aims to examine the dynamic relationship between the internalization of MSs (both individual and multiple) and EPI. To that end, two hypotheses were developed and tested empirically through a longitudinal study based on secondary data.

H1 is partially supported, because all combinations that include ISO 14001 (whether alone, paired with ISO 9001 or ISO 45001, or in triple certification) significantly promote the likelihood of EPI. These results are consistent with previous research identifying ISO 14001 as the certification with the strongest impact on green innovation or EPI (Hernandez-Vivanco and Bernardo 2022). In fact, according to Hernandez-Vivanco et al. (2019), a combination of multiple MSs (probably managed in an integrated or joint way) can be more efficient and sustainable (see Ronalter et al. 2023) when different standards play distinct roles (e.g., ISO 9001 fosters financial improvements while ISO 14001 enhances environmental performance).

However, this study appeared to overcome the rigidness observed by Valero-Gil et al. (2023) and the lack of a direct relationship with product innovations (Wagner 2008; Hernandez-Vivanco et al. 2018). This may be because internalization helps improve system management, enabling capability development that supports EPI. Future research should investigate how barriers observed in previous research appear in the decline phase of the CLC and the extent to which they might reflect insufficient maintenance and/or improvement of these capabilities (Helfat and Peteraf 2003). Another related finding is that the internalization of MSs fosters trust, as the generation of capabilities reduces symbolic implementation motivations (Iatridis and Kesidou 2018) and helps deter unethical or opportunistic behaviors (Desai 2018).

TABLE 4 | Logit model estimates for EPI.

	Logit coefficients				Marginal effects			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Main variables								
Certifications								
ISO9001		**0.313*** **	**0.267** **	0.121		**0.067*** **	**0.057** **	0.026
		(0.115)	(0.118)	(0.123)		(0.025)	(0.025)	(0.026)
ISO14001		**0.650*** **	**0.596*** **	**0.430*** **		**0.140*** **	**0.127*** **	**0.091*** **
		(0.102)	(0.106)	(0.113)		(0.022)	(0.022)	(0.024)
ISO45001		**0.283** **	**0.247** **	0.096		**0.061** **	**0.053** **	0.020
		(0.121)	(0.122)	(0.129)		(0.026)	(0.026)	(0.027)
ISO9001 + ISO14001		**0.798*** **	**0.742*** **	**0.567*** **		**0.171*** **	**0.157*** **	**0.119*** **
		(0.100)	(0.105)	(0.112)		(0.021)	(0.022)	(0.024)
ISO9001 + ISO45001		**0.343** **	**0.293* **	0.122		**0.074** **	**0.063* **	0.026
		(0.164)	(0.167)	(0.168)		(0.035)	(0.036)	(0.036)
ISO14001 + ISO45001		**0.786*** **	**0.713*** **	**0.535*** **		**0.168*** **	**0.151*** **	**0.112*** **
		(0.100)	(0.105)	(0.111)		(0.021)	(0.022)	(0.024)
Triple		**0.842*** **	**0.766*** **	**0.591*** **		**0.180*** **	**0.162*** **	**0.124*** **
		(0.092)	(0.098)	(0.105)		(0.020)	(0.021)	(0.023)
Years certified			**0.026*** **	**0.100*** **			**0.005*** **	**0.011*** **
			(0.010)	(0.024)			(0.002)	(0.003)
Years certified ^{2}				**−0.005*** **				
				(0.002)				
Control variables								
$Slack_{t-1}$ (log)	−0.023	−0.034	−0.034	−0.030	−0.005	−0.007	−0.007	−0.006
	(0.042)	(0.045)	(0.045)	(0.045)	(0.009)	(0.009)	(0.009)	(0.009)
Stakeholder $engagement_{t-1}$	**0.004*** **	**0.003*** **	**0.003*** **	**0.003*** **	**0.001*** **	**0.001*** **	**0.001*** **	**0.001*** **
	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
Environmental $R\&D_{t-1}$	**0.293*** **	**0.285*** **	**0.283*** **	**0.274*** **	**0.061*** **	**0.057*** **	**0.056*** **	**0.055*** **
	(0.079)	(0.081)	(0.084)	(0.083)	(0.016)	(0.016)	(0.017)	(0.016)
Product $responsibility_{t-1}$	**0.007*** **	**0.006*** **	**0.005*** **	**0.005*** **	**0.002*** **	**0.001*** **	**0.001*** **	**0.001*** **
	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
Size (log)	**0.239*** **	**0.201*** **	**0.195*** **	**0.194*** **	**0.050*** **	**0.040*** **	**0.039*** **	**0.039*** **
	(0.027)	(0.027)	(0.027)	(0.027)	(0.005)	(0.005)	(0.005)	(0.005)
Economic openness	**−0.002*** **	**−0.002*** **	**−0.002*** **	**−0.002*** **	**−0.000*** **	**−0.000*** **	**−0.000*** **	**−0.000*** **
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Region (Europe)	**0.329*** **	**0.285*** **	**0.295*** **	**0.286*** **	**0.068*** **	**0.057*** **	**0.059*** **	**0.057*** **
	(0.078)	(0.078)	(0.078)	(0.078)	(0.016)	(0.016)	(0.015)	(0.015)
Year dummies	Yes	Yes	Yes	Yes				
Sector dummies	Yes	Yes	Yes	Yes				

(Continues)

TABLE 4 | (Continued)

	Logit coefficients				Marginal effects			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Constant	**−4.095*** **	**−3.988*** **	**−3.849*** **	**−3.793*** **				
	(0.302)	(0.303)	(0.307)	(0.307)				
Number of observations	19,502	19,502	19,502	19,502				
Number of firms	2769	2769	2769	2769				
Wald χ^2 model	857.88***	915.57***	957.65***	960.52***				
Degrees of freedom	29	36	37	38				

Note: Reference for Certifications: No certifications; for Region: Asia. For marginal effects, delta-method standard errors in parentheses. *Source:* own elaboration.
*$p < 0.10$.
**$p < 0.05$.
***$p < 0.01$.

Also related to H1, no direct relationship is found between ISO 9001 alone, or in combination with ISO 45001, and EPI. One possible explanation for this is the critical role of soft quality management practices in driving innovation (Bourke and Roper 2017; Zeng et al. 2015). In this regard, ISO 9001 may function more as a legitimizing mechanism that reinforces the value of quality practices and engagement within the organization rather than directly promoting EPI. For instance, practices such as quality circles, though simple and low-cost, can significantly enhance the effectiveness of ISO 9001 when implemented afterwards, as they deepen employee involvement and support continuous improvement (Bourke and Roper 2017). This would explain why there is no evidence to support the expected positive effect of ISO 9001 combined with ISO 45001 on EPI. The lack of any effect signals the absence of any focus on EPI itself (Hernandez-Vivanco and Bernardo 2022), because this combination might be more related to process-related motivations (Karanikas et al. 2022; Madsen et al. 2022).

Moreover, H2 is fully supported, whereby the number of years a firm holds at least one certification has an inverted U-shaped relationship with EPI. This implies that the internalization of MSs and its derived EPI capabilities is not constant over time, as commonly assumed in the literature, which is primarily based on cross-sectional studies (e.g., Daddi et al. 2021; Hernandez-Vivanco et al. 2018; Testa, Boiral, and Iraldo 2018; Testa, Iraldo, and Daddi 2018). Instead, capabilities evolve dynamically in line with the CLC concept within the DRBV (Helfat and Peteraf 2003). The following three stages are identified regarding the internalization of MSs certifications analyzed: (i) EPI capability development, (ii) maturity, and (iii) certification idling and the erosion of capabilities. This dynamic view helps at least partially reconcile conflicting findings in the literature on whether MSs have a positive or negative effect on eco-innovation.

Evidence supports this view. Firms with limited certification experience can adopt cleaner product technologies when they integrate QMS, EMS, OHSMS, and CSR practices, but the development of full EPI capabilities requires more mature internalization (Hernandez-Vivanco et al. 2018). As certification experience increases, EPI capabilities development becomes more evident. For instance, Daddi et al. (2021) analyzed a sample of firms that had been EMAS-certified from 3 to 12 years and found a significant effect of its internalization on eco-innovation, which includes process, product, and organizational eco-innovation. The benefits are even stronger when QMSs are also part of the certification strategy (Testa, Boiral, and Iraldo 2018; Testa, Iraldo, and Daddi 2018). However, at advanced stages, rigidities can emerge. Valero-Gil et al. (2023) studied a sample of large multinationals in which more than 90% operate in more than four countries, where a long tradition of MSs certifications is common. The authors found that EMSs often reduced the environmental benefits of eco-innovation, likely associated with the idling stage that leads to the erosion of capabilities.

Also related to H2, the robustness checks related to EPI-design and EPI-use show less evidence of significant capability erosion. This would imply that when firms are more focused on specific EPI objectives, their EPI capabilities are more stable and remain in a mature stage, although the risk of erosion is still present. This aligns with Demirel and Kesidou (2011), who show that MSs can promote capabilities linked to environmental R&D (EPI-design) and the end-of-pipe (EPI-use).

5.1 | Theoretical Implications

This study makes three main contributions to the literature. First, it advances the debate on the relationship between MSs/MMSs and innovation in general (Blind et al. 2023; Manders et al. 2016; Wang and Liu 2023; Valero-Gil et al. 2023), and with EPI in particular (Hernandez-Vivanco and Bernardo 2022; Papagiannakis et al. 2019). More specifically, it unveils that ISO 14001, individually or within MMSs strategies, can promote EPI, whereas ISO 9001 and ISO 45001 only do so when combined with ISO 14001. This extends the conversation regarding the relationship between the number of MSs standards and EPI performance and sustainability (Darnall et al. 2024) by signaling which specific combinations of these standards can be more effective, in this case, for EPI. According to the existing literature, the triple combination of MSs, as the one used in this research, helps organizations achieve

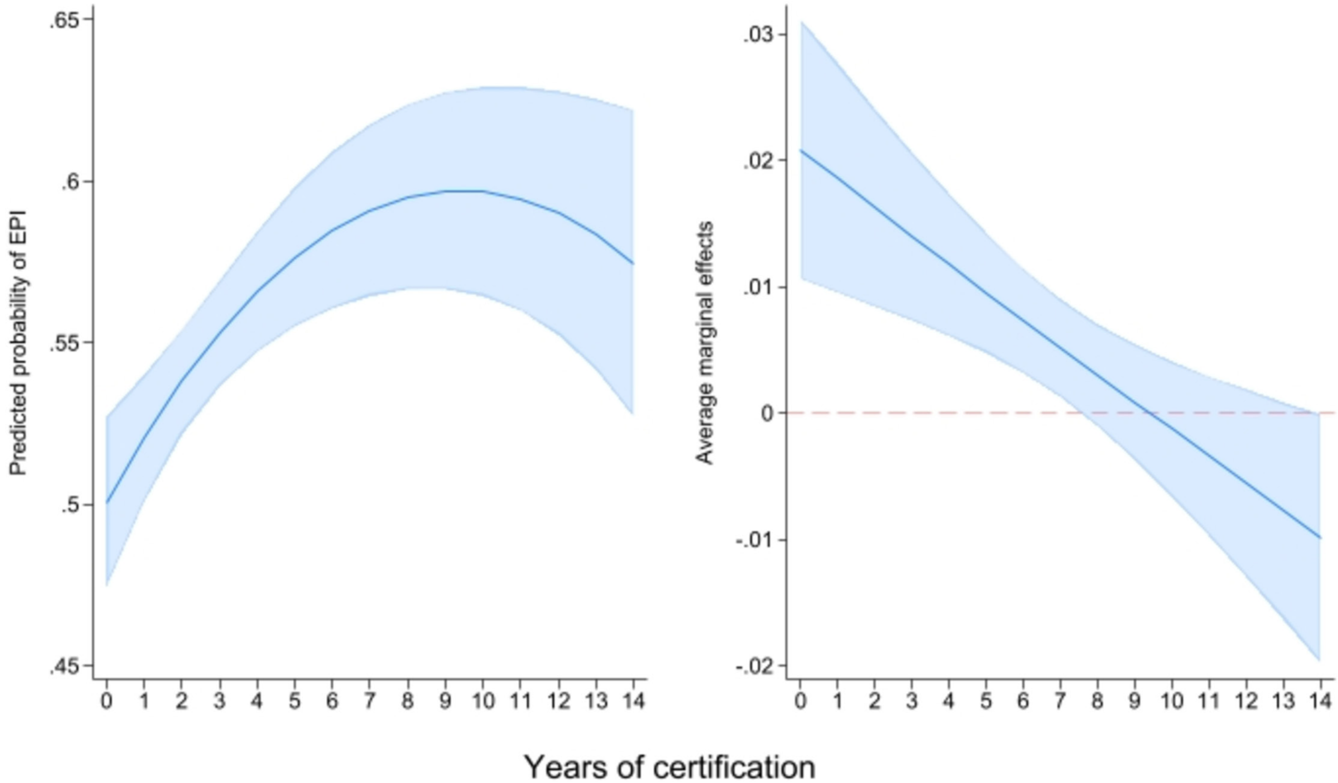

FIGURE 2 | EPI likelihood by number of years a firm has been certified. *Source:* Own elaboration.

better outcomes in terms of innovation (Hernandez-Vivanco et al. 2018; Hernandez-Vivanco and Bernardo 2022), efficiency (Hernandez-Vivanco et al. 2019; Hernandez-Vivanco and Bernardo 2023), and sustainability (Ronalter et al. 2023). In fact, our results show that the triple certification has the largest marginal effect on the likelihood of performing EPI. However, in this study, we did not analyze the effect of having more than three MSSs, and further research is required to determine whether the CLC is not only conditioned by the number of years of implementation but also by the number of MSs in place.

The second contribution is to embed the CLC concept in the DRBV (Helfat and Peteraf 2003). While most CLC research addresses tangible resources (e.g., Ross et al. 2023), this study reveals that capabilities linked to an intangible resource, namely, the internalization of MSs, also evolve dynamically. This challenges the traditional view of MS-related capabilities as static, showing instead that they can become eroded over time (Heras-Saizarbitoria and Boiral 2015). As Ross et al. (2023, 1341) note, "resource idling can be detrimental to a firm's sources of competitive advantage that it has been built over time." However, certification idling should be recognized in the MS certification literature as a predecertification stage, because innovation capabilities are already weakened before decertification occurs (e.g., Clougherty and Grajek 2023). Complementary practices could also indirectly help sustain CLC trajectories and prevent the erosion of capabilities and should therefore be considered too (Zeshan et al. 2025).

The third contribution is methodological. With very few exceptions (e.g., Heras-Saizarbitoria and Boiral 2015), the literature is dominated by cross-sectional and survey-based studies, with the associated problems around subjectivity and response bias (Heras-Saizarbitoria and Boiral 2013). However, longitudinal studies are also necessary to advance DRBV research (Helfat 2000), and we contribute by providing an objective measurement of the CLC associated with the internalization of MSs based on secondary longitudinal data (Heras-Saizarbitoria and Boiral 2013).

5.2 | Practical Implications

The findings of this study offer several practical implications for managers and decision-makers involved in the adoption and implementation of MSs and EPI. First, the results indicate that internalizing ISO 14001, either individually or as part of MMSs, can positively support the development of EPI capabilities. Firms aiming to improve their environmental innovation performance should therefore not only adopt that certification but also ensure it is meaningfully integrated across the organization and aligned with broader sustainability strategies. Doing so also helps build trust in the implementation of these practices.

Second, the lack of significant effects of ISO 9001 and ISO 45001, alone or in combination, on EPI underlines the importance of moving beyond symbolic adoption. Firms relying solely on QMSs and/or OHSMSs may need to strengthen the link between their quality initiatives, occupational health and safety, and environmental objectives, particularly through soft practices such as quality circles, employee engagement, and knowledge-sharing mechanisms that support innovation.

Third, the confirmation of an inverted U-shaped relationship between certification duration and EPI highlights that the benefits of internalizing MSs are not constant over time. It is important for managers to be aware that the benefits of certification-related capabilities may change over time. As systems mature, continued investment, regular follow-up, and a willingness to adapt are required to ensure they remain effective. This is particularly relevant for firms that have held certifications for many years, where the risks of capability erosion or symbolic certification are higher.

Finally, firms that focus on specific EPI goals, such as design or end-of-pipe innovations, appear more likely to sustain mature capabilities over time. This implies that setting clear innovation-oriented objectives within MS implementation can help stabilize capability performance and reduce the risk of capability erosion.

5.3 | Limitations and Future Research

This study is subject to certain limitations related to data availability and variable measurement. While revisions of ISO standards were accounted for at the contextual level, specific versions implemented at the firm level (Fonseca et al. 2022; Manders et al. 2016) were not considered. In our study period, most OHSMS certifications were under OHSAS 18001, meaning the evidence specifically related to the more recent version of the standard ISO 45001 is not fully captured. Moreover, other contextual factors, such as local or sectoral regulatory and institutional pressures (Demirel and Kesidou 2011), were not included in the analysis. Future research could address these limitations by applying multi-level modeling techniques or incorporating richer contextual data.

Furthermore, although MMSs were analyzed in a similar fashion to Wang and Liu (2023), more detail is required regarding the level of integration of MSs (Bernardo et al. 2009) and the process for improving that integration (Abisourour et al. 2020), as these factors could also affect (sustainable) innovation outcomes (Bernardo 2014; Hernandez-Vivanco et al. 2018).

Future research should also analyze the effects of implementing additional sustainability practices and standards, including outcome-focused standards (e.g., the International Labor Organization's Fundamental Principles and Rights at Work) or hybrid frameworks (e.g., United Nations Global Compact) to better understand the dynamics of international sustainability standards beyond the process-focused ISO certifications analyzed here (Darnall et al. 2024).

Additional environmental practices could also be analyzed. For instance, in certain sectors, circular economy models may impact innovation and eco-innovation in a different manner to generic standards (Abbate et al. 2025). Future research should also explore mechanisms to prevent capability erosion and instead promote renewal, redeployment, or recombination when firms are in the mature stage of EPI capabilities. The roles of other sustainability-oriented certifications, such as B Corp, are worth examining here (Fonseca et al. 2022; Forliano et al. 2024). Finally, scholars should consider the full certification life cycle in future research, including certification, decertification, and certification retrieval (Hernandez-Vivanco and Bernardo 2023), which mimics the concept that competitive advantage is resource-intensive to develop (certification), quick to destroy (decertification), and hard to resuscitate (retrieval) (Le Breton-Miller and Miller 2015).

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Appendix A

TABLE A1 | Description of Eikon variables.

Variable	Description
EPI (*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	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)

Source: own elaboration, based on Eikon questionnaire.