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What Fosters Eco-Innovation in European SMEs? A Conceptual Framework and Empirical Evidence Across Micro, Meso, and Macro-Factors

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Abstract

Due to the changing climate, an increasing number of organizations are focusing on Eco-Innovations (EIs). In this study, we present a currently missing conceptual framework that classifies the determinants of EI across micro-(firm), meso-(intersectoral), and macro-(policy) dimensions. Based on a comprehensive review of the literature and its existing gaps, this framework comprises three levels and six categories (financial, technical, organizational, market, collaboration, and legal) with fourteen unique drivers and ten barriers. Theoretically, the EI framework is grounded in the Porter hypothesis and social network theory. To test the framework, novel secondary data collected from almost 11,000 European SMEs was employed. The baseline results using Logit and Poisson regression were used to empirically validate the framework, and moderation analysis revealed an interplay among the three levels. In addition to financial resources and technical expertise, meso-level cooperation is one of the most relevant factors for organizational EI actions. The meso-level arguably serves as an adhesive between the micro- and macro-levels. Furthermore, due to the ambiguous and dynamic implications of the Porter hypothesis, barriers—mainly located at the macro-level—may also foster EI. Therefore, this paper provides valuable new strategic insights for organizations aiming to adopt EI.

Keywords: eco-innovation; circular economy; European Union; SMEs

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1. Introduction

The global temperature is undeniably rising due to resource overuse. The 2030 Sustainable Development Goal (SDG) Framework of the United Nations (UN), particularly SDG12, focuses on the need for responsible consumption and production, which includes Circular Economy (CE) concepts and improved resource efficiency [1,2]. In 2025, the UN revealed that only 35 percent of SDG-related targets are on track [3], indicating a need for greater commitment and action.

To achieve sustainability through climate action, the European Union (EU) has approved the European Green Deal to become a "modern, resource-efficient and competitive economy" [4]. It targets large public corporations and specifically Small and Medium-sized Enterprises (SMEs) in the EU to implement action and investment plans in environmental

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innovations (Shortly Eco-, EIs) [5–7]. Since SMEs make up 99.8% of all registered firms and add up to 53% of the total economic value in the EU, investments in EI significantly impact the environment and firm growth [7,8]. European organizations aim to identify effective investment strategies and align their organizational practices with the drivers, barriers, and contextual conditions required to foster EI [2,9]. Therefore, the EU represents a governance system that is aligned with achieving green transition by stimulating organizational EI actions, making it a suitable context for understanding EI determinants. For instance, to understand driving factors of EI, on the one hand, patent application analysis of the EU demonstrates a clear global comparative advantage in EI research and development, thus signifying policy relevance for other regions [10]. On the other hand, from the barrier perspective, the EU faces a productivity gap, appears to remain stagnant in "mature technologies", and lacks a strong manufacturing base in EI [10,11]. From 2010 to 2024, the circular material use rate of the EU improved from 10.7% to merely 12.2% [12]. Recently, an EU-wide survey estimated that almost 70% of municipalities lack experts with environmental and climate assessment skills [13]. This highlights a staggering gap between the willingness and ability to achieve green transition within EU SMEs. In this paper, we leverage these interesting tension dynamics of the Science–Industry–Policy nexus to examine organizational-level EI action and its determinants.

Regarding this transformation, ongoing research is being conducted on EI and CE regarding definitions [14–19], theories [20–23], and innovation determinants [22,24–30]. Here, we follow [16] and consider EI as a novel concept for an organization, reducing environmental risk and damage. CE is explored in the works of [17,31,32] and is understood as an economic system used to reduce, reuse, recycle, and recover. Different theories motivate underlying structures for fostering or hindering the organizational adoption of EI, including resource-based views of the firm, stakeholder theory, the institutional theory, Porter hypothesis, and dual-market failure concerns [14,20,21,27,33]. However, despite clear hints of the multifaceted theoretical nature and systematically integrated complexity of EI, the literature gap lacks a comprehensive framework [34]. There are vocal advocates for considering sustainable development not only at a single analytical level, but rather across interconnected levels, namely, from the micro-, meso-, and macro-level [35,36]. Most significantly, this "conceptual myopia" has ignored the meso-level intersectoral dynamics alongside the micro- (organizational level) and macro-level (policy level) determinants, resulting in ineffective and fragmented policy interventions [34]. This critique requires the removal of the analytical divide between the three levels and integrating comprehensive acknowledgment of interconnection. To this end, the literature on EI has begun to propose the development of more comprehensive conceptual frameworks. Nevertheless, existing studies addressing micro-, meso-, and macro-level perspectives have largely relied on literature-based analyses or qualitative approaches [16,35,37]. Moreover, the majority of research has focused on identifying drivers of EI [15], whereas barriers and their reciprocal interrelations remain comparatively underexplored and require further systematic examination. Consequently, the literature lacks a theoretically elaborative comprehensive framework that simultaneously identifies and integrates barriers and drivers. Moreover, there is a lack of empirical evidence that measures such an integrated conceptual framework across the three levels, broad categories, drivers, barriers, and further moderating associations.

This study addresses this crucial gap in five different ways. First, in this study, relevant theoretical arguments were gathered to motivate the reconsideration of EI as a complex systematic phenomenon and present an integrative framework to conceptually classify the factors that foster EI. We conceptualize and classify EI-fostering factors across three levels, six different categories, and between drivers and barriers. Theoretically, from a management standpoint, the contemporary literature on EI recognizes crucial firm-level

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determinants (e.g., financial resources, technical skills, market demand) framed within the resource-based view of the firm and stakeholder theory [20–23,25]. To expand this micro-organizational perspective to the macro-EU context and the interconnection of the two levels through the meso-level, this study combines the argumentation of the social network theory and Porter hypothesis. Second, we employed a large novel survey dataset consisting of almost 11,000 SMEs to perform a quantitative analysis that was long overdue in the face of the evolving (formal and informal) institutional context. In this quantitative classification of EI drivers and barriers, Logit and Poisson regression were employed, providing a robust understanding of associative relationships between EI and its drivers and barriers. Third, we extended this empirical analysis to address the ignorance of the meso-level and conducted moderation analysis to motivate further research on the reliance between meso-, micro-, and macro-level drivers. Fourth, we add to the paradoxical, ambiguous dual nature of barriers based on the Porter hypothesis, which claims that environmental regulations may lead to a competitive advantage over time, even though they are often initially considered a barrier for organizations [38,39]. In our quantitative analysis, we rely on this hypothesis to detect a partial dynamic relationship between EI and its barriers. Fifth, altogether, we provide theoretical and practical directions for stimulating EI actions, mainly specific to the EU and SMEs context and extrapolated for other regions and organizations. For instance, at the meso-level, cooperation between EU SMEs has the largest positive association. Through moderation analysis, meso-level factors such as external support, assessment tools, and cooperation were found to support EI actions in financially and technically constrained small firms. Thus, the theoretical exploration of meso-level factors and policy design to foster these factors is substantiated through our work.

Section 2 of this paper focuses on the extensive exploration of the theoretical background and literature review regarding our topic, leading to the identification of contemporary gaps. Section 3 yields a comprehensive EI framework comprising three levels and six categories. As discussed in Section 4, this framework was empirically applied and tested. In Section 5, we present our results, as well as a discussion and the implications in Sections 6 and 7, respectively. Finally, in Section 8, we conclude the paper.

2. Literature Review: Determinants of Eco-Innovation

Innovation is crucial to fighting climate change and becoming more sustainable [2,40]. Organizations strive to integrate sustainability into their strategies and to pursue resource-efficient innovations [41–43]. In the literature, EI, "environmental innovation", "green innovation", and "sustainable innovation" are used interchangeably, enabling organizations to achieve sustainable transformation, avoid environmental damage, and create competitive advantages [2,14,15]. EI is understood as "the production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organization [. . .] and which results [. . .] in a reduction of environmental risk, pollution and other negative impacts of resource use" [16]. It is related to a specific activity; e.g., the Edding group—an international family business based in Germany—installed return boxes for its unused pens to recycle them. On the broader industrial level, EI is embedded in the concept of CE, which refers to an entire economic system [17] in which the waste of one organization is used as input for a cooperative partner. CE is an "economic system that is based on business models which replace the 'end-of-life' concept with reducing, alternatively reusing, recycling, and recovering materials in production/distribution and consumption processes" [17,19]. A prominent example is the Kalundborg Symbiosis in Denmark, where industrial companies exchange waste and resources (e.g., steam, sludge, fly ash, or hot water). CE and EI are closely related but conceptually distinct: CE is a system-level economic model, while EI is a firm-level innovation activity that can support the model. In this paper, we use the term EI to refer to all innovative activities on an organizational level that contribute to resource efficiency. From a definitory perspective, this might overlap with CE activities executed on an organizational level, for example, 1. saving resources through reducing and reusing (saving water, energy, materials, and less waste), 2. using more sustainable resources through recycling and refurbishing (renewable energies, greener supplies, recycling), 3. innovating through rethinking and repurposing (selling waste, product design), or a combination of the three. These actions occur at an organizational level and result in higher resource efficiency. However, they are not sufficiently "advanced" to be called CE since they are not occurring in an entire economic system such as the Kalundborg Symbiosis.

Recently, increasing attention has been paid to the connection between organizations and their transition to resource efficiency through EI [15,42–45]. The literature conceptualizes EI through multiple theoretical lenses, including a resource-based view, institutional theory, and stakeholder theory [20,21]. The resource-based perspective emphasizes internal organizational resources and competences [22], whereas institutional theory highlights the role of external pressures, including regulatory requirements and normative expectations, in shaping organizational environmental behavior [23,25]. Stakeholder theory underscores the influence of various stakeholder groups (customers, investors, communities, employees) in driving or constraining green innovation efforts.

Regarding methodological approaches, there is a mix in this field that underlies steady progress. Most studies in this field concern a literature review or attempt to assimilate different arguments to advance conceptualization [15,46,47]. For example, Reference [46] conducted bibliometric analyses and identified four antecedents or enablers of how organizations become more resource-efficient in terms of, for example, the institutional environment and resources, which are particularly important. A few sources follow a qualitative research design using case studies or interviews [41,48]; however, a few sources apply quantitative methods such as meta-analyses [49] or structural equation modeling [50]. There is also a wide range of sample sizes, ranging from the analysis of four cases [51] up to that of more than 6000 innovative Spanish manufacturing and service firms [52].

With regard to analysis level, most studies demonstrate a limited depth [19,46,53,54]. Such studies mainly use the differentiation between internal and external factors [41,55,56]. Other studies focus on the institutional frame as a specific level in their article [43,45,48,57]. Only a few studies propose several layers. For example, Reference [15] conducted a systematic literature review in which they structured the literature according to micro-(e.g., resources and capabilities), meso-(e.g., market, networks), and macro-levels (e.g., policy). Similarly, the authors of [58], in their bibliometric analysis, cluster their results according to macro-, meso-, and micro-levels following a similar logic. From an evolutionary economics perspective, the authors of [34] examine complex socioeconomic ecosystems and sustainability transitions using a macro–meso–micro-framework. However, their analysis relies on qualitative investigation based on a neo-institutional theoretical background.

The literature review reveals a complex interplay of internal organizational (e.g., resources) and external factors (e.g., regulations). Regarding drivers and barriers, not all articles differentiate them. Predominantly, the studies [47,50] refer only to analyzing factors or determinants of EI in general without specifically declaring drivers or barriers [15]. Reference [59] focuses on drivers only, whereas references [2,39,60] only consider barriers in their analyses. Typically, research identifies drivers and barriers for EI as dimensions of financial resources, technical issues, organizational factors, and market collaboration and regulation [38,55–57,61].

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Generally, and in line with innovation management, access to financial resources enables EI. They can be provided as internal resources or external financing through bonds, loans, investment funds, or governmental incentives [22,62]. Limited capital availability, high upfront investment costs, and uncertain return on investment create substantial obstacles for organizations seeking to implement EI [23].

Technically, developments in, e.g., renewable energy, materials science, and digital technologies provide tools and solutions to enable EI by creating new possibilities for environmental improvement [22,25]. Inadequate technical infrastructure and skills, however, prevent organizations from effectively adopting and utilizing environmental technologies [58]. Technological path dependency represents a barrier, as existing technological investments and competencies create lock-in effects that discourage EI [22,63].

Several studies have identified an organization's internal resources, competencies, and eco-friendly corporate culture as crucial drivers for EI [22,26]. Organizational cultures that prioritize sustainability, environmental responsibility, and innovation create supportive environments for EI. Additionally, organizations invest in employee training, knowledge sharing, and continuous improvement processes to develop technical competencies that support EI [15]. Organizational learning can either be seen as a driver or barrier, since it may impede radical EI by reinforcing existing routines and creating resistance to fundamental change [22].

Confirmatory and risk-averse enterprises with formal and hierarchical patterns might also hamper EI, referring to how traditional innovation management, organizational size, and structure influence EI [15]. Therefore, micro- and SMEs face unique organizational challenges, including limited managerial capacity, a lack of dedicated environmental management personnel, and competing priorities that relegate sustainability initiatives to secondary importance [64].

In this context, an important aspect for successful EI is collaboration. Organizations with access to either knowledge or technologies through collaboration can leverage external knowledge and complement internal R&D capabilities [24]. Partnerships with suppliers, customers, research institutions, and other stakeholders facilitate knowledge transfer and resource sharing that enable green innovation [29].

The current literature on determinants of EI highlights the importance of the market. Generally, stakeholder pressures from multiple constituencies are associated with EI adoption. Customer demands for sustainable products and services create direct market pressures that induce EI [15,20,58] and stimulate demand. Investors increasingly incorporate environmental, social, and governance (ESG) criteria into investment decisions, creating financial incentives for green innovation. Regarding barriers, adoption of EI might then be slowed due to a low market demand and the limited availability of green suppliers and materials impeding implementation [29].

The regulatory settings (e.g., taxes, emission trading schemes, subsidies) are important because regulatory requirements motivate organizations to adopt EI to meet legal obligations and avoid penalties [15,25,58]. The EU, which has stringent environmental regulations, demonstrates higher rates of EI adoption [22,23,25,26], which is in line with the Porter hypothesis. Conversely, regulatory complexity generates confusion and incurs compliance costs, particularly for SMEs with limited legal and regulatory expertise. Thus, the relationship between barriers and drivers varies significantly across geographical settings [20,25,30]: European contexts demonstrate strong regulatory drivers and institutional support for EI, while Asian contexts show growing market drivers and competitive pressures. Regarding the industry sector, manufacturing sectors face different challenges and opportunities compared to service sectors. Industries with high environmental impact face stronger regulatory pressures and stakeholder scrutiny, creating more powerful drivers for EI [23,29].

The synthesis of barriers and drivers of EI in existent research reveals several important theoretical insights that shape our proposed framework and empirical approach. However, there are major shortcomings and therefore research gaps for our work to address. First, EI is best understood through an integrated framework that combines multiple theoretical perspectives [15,34]. Resource-based, institutional, and stakeholder theories each capture important aspects of EI determinants, but none alone provides a complete explanation [20,22]. Therefore, we combine theories in order to take the complexity of the EI framework into consideration. Social network theory argues that innovation is strongly shaped by the relationships between actors [65]. Through a social network, organizations exchange information and receive access to resources; thus, a social network is relevant to the successful implementation of innovation [66]. In addition, this paper attempts to understand the Porter hypothesis regarding EI through a partial dynamic analysis, which claims that environmental regulations, which can be a barrier for organizations [38,39], may lead to a competitive advantage [14]. This is important since the transition from traditional organizations towards EI is associated with tensions, e.g., from suppliers, customers, stakeholders, and society as a whole [2,44]. Another shortcoming of existing research towards an integrative framework of EI is the level of analysis. Some studies do not provide a comprehensive assessment of relevant factors across different levels and instead adopt a broad approach. This paper addresses factors of EI across three different levels: at the micro-, meso-, and macro-level. Whereas the micro-level represents the internal factory, the macro-level takes external factors into account. Most importantly, and grounded in social network theory, this paper identifies collaboration at the meso-level to be a fruitful avenue for the future exploration of resource-efficient organizations [2,15,24,67]. Collaboration is an inter-organizational relationship focused on achieving common or firm-specific goals [37]. Organizations collaborate by working towards these goals, building trust, social learning, developing joint processes, and sharing costs or information [68,69]. By including collaboration as a unique meso-level aspect, we propose a first-of-its-kind EI framework and extend previous research to highlight the role of crucial technological and organizational knowledge transfer [24,40,57].

Second, the dual nature of certain factors (acting as both barriers and drivers in different contexts) highlights the complexity of EI processes [22]. While studies in this field have increased in recent years, the main works have focused only on literature analysis (e.g., [20,53,70]). Whereas most studies have analyzed drivers of EI, only a few articles have considered barriers. This is important, since SMEs face higher hurdles than other (larger) organizations [60]. This suggests that simple linear models of EI may be inadequate and that more nuanced frameworks accounting for feedback loops, paradoxes, and contextual moderators are needed. This is accomplished through the investigation of the role of both drivers and barriers alike, since one factor might be more fruitful in one way or a hindrance in another way. For example, the role of regulation is the dominant barrier studied in previous research. In this paper, we show that other barriers may behave similarly, as we find that barriers are reported by both innovating and non-innovative firms. Thus, barriers are eventually ambiguous factors that may be the cause of resistance and, in some cases, of complete hindrance.

Third, our paper contributes to prior research methodologically. Current research primarily consists of literature reviews [70,71] or qualitative analyses (e.g., case studies [51,72]). There is a strong need to employ appropriate updated data and conduct a quantitative analysis of organizations and their resource efficiency [56]. This will help us update the consistency and current relevance of the previously available pioneering empirical evidence

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on drivers and barriers. Under institutional theory, this is essential because the (formal and informal) institutional context within which organizations are embedded constantly evolves. For example, changes in coercive external factors (laws and regulations, e.g., European Green Deal), normative pressures (industry standardization and expectations, e.g., label and certification), and mimetic pressures (demand for similar environmentally friendly products) are relevant to measuring EI and require recent evidence [73]. Using a novel dataset of almost 11,000 European SMEs and by conducting plausible regression analysis, we significantly contribute to addressing this gap with novel variables. In addition, we provide novel evidence of interactive interplay among the three levels. For example, smaller financially and technically constrained organizations are benefiting more by using meso-level opportunities (e.g., external support) to adopt EI.

Overall, our research addresses the claims of recent work claiming that "although the debate on the adoption of environmental innovations is well underway, the discussion on Eco-Innovation in the context of SMEs is at a less developed stage and deserves more attention, especially given the relevance of these companies in the economic system of several countries" [46] (p. 1432), which is particularly relevant given that SMEs face resource constraints to deal with constantly demanding legal costs and a lack of bargaining power towards their suppliers [74].

3. Three-Level Driver and Barrier Framework for Eco-Innovation

To present an integrated framework, we build on the Section 2. The majority of the existing literature—such as [38], who distinguish between financial, market, legal, technical, and organizational categories—focuses on identifying drivers and barriers to EI (e.g., [20,51,60]), yet largely neglects a systematic differentiation across analytical levels. Only a limited number of studies explicitly incorporate such levels and assign previously identified factors accordingly. Reference [56] classifies organizational and financial factors, resources, product development, collaboration, and internal stakeholders as internal, while assigning policy and regulatory frameworks, supply chains, infrastructure, environmental conditions, and consumers to the external dimension. Similarly research by [55] follows a comparable approach, categorizing similar factors within internal and external levels. Likewise, ref. [49] adopt this distinction, although they diverge by allocating collaboration and technology to the external level. Ref. [29] represents one of the few exceptions by introducing a three-level framework; however, their analysis is more industry-specific, distinguishing between internal, intra-industrial, and inter-industrial levels. In contrast, refs. [15,34] employ a more generalizable three-level framework comprising micro, meso, and macro-levels. Within this perspective, the micro-level refers to the organizational level and encompasses factors such as firm performance, competencies, resources, reputation, and cost efficiency. The meso-level captures inter-organizational dynamics, including networks and programs; ref. [15] further emphasizes market conditions and customer needs within this level. At the macro-level, both studies highlight the role of policies and institutional frameworks.

Following the literature, we justify our conceptual classification of the macro-level emphasizing the role of institutional context in the successful adoption of EI actions [43,75]. Institutional macro-factors such as regulations, standards, and certifications can heavily affect the transition to a more sustainable organization [15,20,43,57–59,67]. On the one hand, a coercive regulation design can lead to comparative advantages based on resource efficiency and normative reputation through standardization certifications (e.g., ISO 14001) [76] and product labels. On the other hand, the compliance costs, incompatibility, and complexity of such regulatory designs are considerable barriers.

Micro-level factors focus on the internal level of an organization. Reference [56] differentiates between internal and external drivers and barriers and argues that this is "one of the most widespread approaches in the extant studies" (p. 4). Internal drivers and barriers refer to determinants that belong to the organization itself, referring to its resources or characteristics [39,40,42,46,54,61]. Therefore, this internal perspective is considered the micro-level and includes financial, technical, and organizational categories in the proposed framework.

Between the two levels, the micro and macro, our framework includes a kind of intermediate inter-sectoral meso-level. Reference [44] found that collaboration is a key instrument in this process. Similarly, Reference [43] emphasizes the importance of connecting the different levels and highlights the "co-evolution" of the micro- and macro-level since they are "highly variable and contextual through complex interplay with both internal, corporate factors (micro-level), and external, societal factors (macro-level)" (p. 542). This is particularly true for EI, as it is even more challenging for organizations due to the multiple requirements of different stakeholder groups. Hence, the meso-level comprises market and collaboration categories and serves as an adhesive between the other two levels [15,24].

Additionally, the temporal dimension matters, as barriers and drivers evolve over time. In particular, our framework considers the time dimension of the Porter hypothesis; temporal shifts naturally occur when hurdles have been overcome in the past and then turned into drivers to accelerate EI [9,14]. To illustrate this, in Figure 1, the left-hand arrow extends over the present (t = 0), past (t − n), and future (t + n) to represent the partial dynamic properties of the framework. These observations are supported by the Porter hypothesis and empirically reflected in the survey data (see Supplementary Table S1). While the barrier variables refer to past constraints, the driver variables capture future-oriented incentives, and the EI approach reflects firms' current strategic orientation. This approach further enables us to understand the ambiguous role of the barriers, whether they are merely factors of resistance or completely hinder EI.

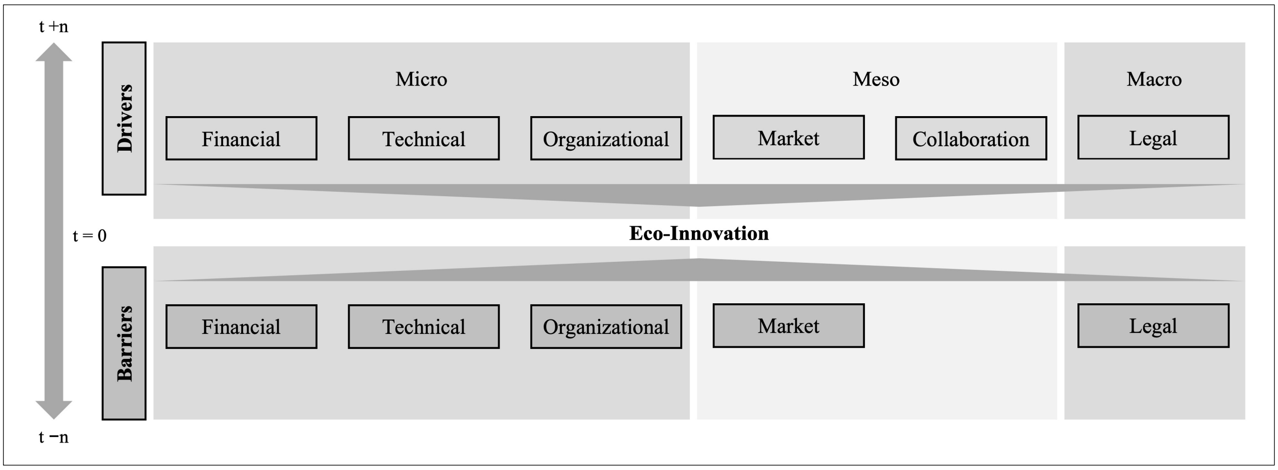

Figure 1. EI framework with driver and barrier categories at the micro-, meso-, and macro-levels.

Table 1 provides succinct theoretical reasoning for the allocation of different drivers and barriers into different categories, as visualized in Figure 1.

Table 1. Specific drivers and barriers of EI framework.

Level	Category	Drivers	Barriers
Micro	Financial	direct financial support, incentives, and investments in EI, encouragement due to subsidies or financial advice [22,56,61,62]	costs of environmental investments, especially if managers are not well informed [23,55]
	Technical	technical expertise within organizations [22,25,46,49,50]	lack of environmental expertise, lock-in effects [22,39,55,58,63]
	Organizational	consultancy services can help reduce/overcome knowledge barriers [15,22,26,77]; firm size and firm age are relevant because larger and older organizations usually have a greater innovation capability due to more resources [20,46,49,52,64]; successful innovations need to be accepted by the market and its Business-to-Consumer (B2C), Business-to-Business (B2B), and Business-to-Government (B2G) [72,78]; different stakeholder pressures as motivators for organizational improvement, which can become a competitive advantage [15,20,51,58,67,79]	difficulty in deciding on strategic EI actions, such as the internal skill development strategy or circularity strategy [9,22,48,63]
Meso	Market	lifecycle assessment tools [80] and demonstrations like demonstration sites for testing in real-life settings [81] may help organizations understand their level of EI	lack of demand [15,19,20,46,49,58] and lack and complexity of biodegradable supply materials [9,29]
	Collaboration	multidisciplinary and cross-sectoral collaboration as a driver for innovation in general [48,82], specifically regarding EI [24,29,46,47]; external support as an overarching form of support that focuses on inter-organizational relationships [37]; the database acting as a common ground of shared knowledge and information [69]	
Macro	Legal	claims such as the "Supply Chain Act" demonstrate the role of the EU in striving more towards EI since they implement new rules [15,25,58,83]; e.g., the rules of material usage and recycling should be clear for all stakeholders [19,46]	high administrative complexity or when the technical requirements of legislation are not up to date [41,49]; independent labeling and certification

From a theoretical point of view, integrated micro–meso–macro-levels fostering EI can be supported through a combination of the Porter hypothesis and social network theory. According to the Porter hypothesis, the introduction of more stringent regulations can minimize uncertainty for organizations. Regulations incentivize organizations through environmental or transport taxes, creating demand pressure and rewarding them if they exceed current standards, and they may even create new standards [2,14,40,84]. However, an issue of double externality may arise, and EI might be underproduced [33]. Looking at the micro-level of the EI framework, the Porter hypothesis posits that sufficiently stringent but well-designed environmental regulation can trigger firm-level EI, the efficiency gains of which more than offset compliance costs, thereby enhancing productivity and competitiveness rather than merely imposing a regulatory burden [39,42,46,54,61]. At the macro-level, the Porter hypothesis is interpreted in terms of national or regional competitiveness, suggesting that ambitious environmental policy can generate economy-wide EI waves, upgrade factor and demand conditions, and create comparative advantages in clean technologies, even though these aggregate effects are empirically harder to identify due to the heterogeneity of institutions and cross-sectoral interactions [14,15]. In doing so, the micro-level is affected by the macro-level, representing a relationship between them.

In addition, while micro-level analyses focus on firms' internal capabilities (such as in terms of resources and capabilities) and macro-level perspectives emphasize regulatory pressures, social network theory operates at the meso-level of inter-organizational relationships. It explains how the relationships amongst actors determine access to information, resources, and influence, and thereby affect outcomes such as innovation and performance. In this view, both the emergence of innovations (who comes up with them, with what novelty) and their further development and commercialization (who obtains resources, endorsements, and collaborators) systematically depend on cooperative activities within this setting. Thus, organizations embedded in dense collaboration networks—such as alliances, R&D consortia, clusters, or supply chain partnerships—are posited to gain access to knowledge, complementary resources, and trust-based coordination that amplify the positive effects of environmental regulation on EI [43,67]. Organizations that cooperate might attain stronger innovation offsets due to environmental regulations compared to structurally isolated firms, because connected organizations make use of, e.g., diverse green technologies and recombine regulatory insights from multiple disconnected partners [24,66]. Additionally, cooperation makes it easier to implement and scale risky EI under regulatory uncertainty. Reference [85] supports this notion by showing that networked firms have higher EI intensity when facing stringent environmental policies, as their position facilitates faster learning, reduced search costs, and collective lobbying for flexible regulation that aligns with Porter-style innovation offsets. Thus, this meso-level integration bridges firm strategy with systemic policy effects, offering a comprehensive integrated lens on how network governance turns regulatory constraints into competitive green advantages. With this background, the proposed integrative framework captures the complex interplay of internal and external factors influencing EI.

4. Materials and Methods

4.1. Data and Sample

To quantitatively address the highlighted research gaps, we employed a novel cross-sectional survey dataset, Flash Eurobarometer 498: SMEs, Resource Efficiency and Green Markets [86]. This survey was conducted on behalf of the European Commission to provide evidence-based policy support on industrial management and its role in shaping the EU's Green Transition strategy [87]. The geographical scope of the data includes 27 EU member states and 8 other non-EU countries relevant to this strategy (e.g., the USA, UK, Türkiye). Thus, this dataset was inherently designed for an empirical comparative analysis. The unit of analysis is businesses employing 1 or more people, as defined by the EU's statistical classification of economic activities (NACE). Therefore, under the EU's definition of SMEs, micro, small, medium, and large companies were interviewed. Methodologically, companies were sampled using a non-probability quota sampling process and underwent Computer-Assisted Telephone Interviews (CATIs) in November–December, 2021.

Our analysis focuses on micro- and SMEs operating within the 27 EU member states. Our classification is based on the standardized definition of SMEs by number of employees, and our final sample consisted of 10,896 firms meeting these two criteria and post-variable creation and management procedures. In addition to the previously mentioned theoretical motivation for our focus on EU-27 SMEs, we also leveraged the approximated institutional uniformity within a supranational innovation system such as the EU [88]. This offers, to some extent, regulatory homogeneity and comparable exposure to the external pressures.

4.2. Variables

Our main dependent variable was derived from a survey question asking respondents whether they are taking the listed actions to be *more* resource-efficient. Based on the typology and standardized definition of EI emphasized in Section 2, we interpreted these actions as organizational changes aiming to achieve higher levels of resource efficiency, which predominantly represent process and organizational EI. Accordingly, the study focuses on the breadth of implementation of EI organizational actions. To strengthen our argument, we followed the work of [89], which demonstrated that within the Practice-Based Approach (PBA), the traditional outcome-based definition of EI ignores systemic and organizational practices through which EI is enacted. Due to the composite nature of organizational practices, concerning actors, actions, resources, and value creation, this approach offers a departure from Eco-Innovation to "eco-innovating," defined as the shared use of ongoing practices. Formally, empirical evidence also supports that the environmental practices are associated with products, processes, and organizational EIs [90]. To cross-reference practice-based operationalization, we additionally conducted a supplementary analysis using a nested variable that can be considered a close proxy for a traditional outcome-based EI. Our analysis results showed a mediating relationship between our practice-based definition of EI and the traditional outcome-based definition. However, we refrain from working with this variable due to its nested nature.

After establishing this conceptual positioning, we utilized two complementary versions of our dependent variable. In the first approach, we regrouped practices into a binary categorization (EI). The second approach hedges against information loss and provides supplementary consistency to our conceptual classification of the determinants of the EI. This was achieved by creating an additional count variable (EI Breadth). Our variables are detailed in Supplementary Table S1.

Our main independent variables are the determinants of EI specified based on the literature review and proposed framework. These variables were derived from a survey question that allowed multiple answers; therefore, concerns of multivariate analysis were considered. However, based on the correlation and multicollinearity analyses, such issues were not detected.

Note that, as mentioned, the formulation of the survey questions can be interpreted to have a time dimension. Driver-related items are forward-looking as firms are asked which forms of support they would rely on to conduct more EI actions. In contrast, barrier-related items are retrospective, as firms are asked whether they encountered difficulties when trying to set up EI actions. Therefore, while our dataset remains cross-sectional and static, the survey questions tap into the organization's past experiences and future expectations. This setting offers illustrative insights that can be interpreted as a partial dynamic, making it feasible to frame it under the Porter hypothesis and understand the ambiguous dual role of barriers.

Moreover, to the best of our knowledge, some of the drivers and barriers listed in this question are unique and contribute to the literature. In particular, in the driver section, "assessment tool" and "demonstration" are new variables. The barrier "complexity with labeling" is a new variable, based on previous reports, and reflects ongoing discussions on this topic [91].

In Figure 2, the levels and categories are populated with the selected variables, as detailed in the comprehensive argumentation provided in the previous sections.

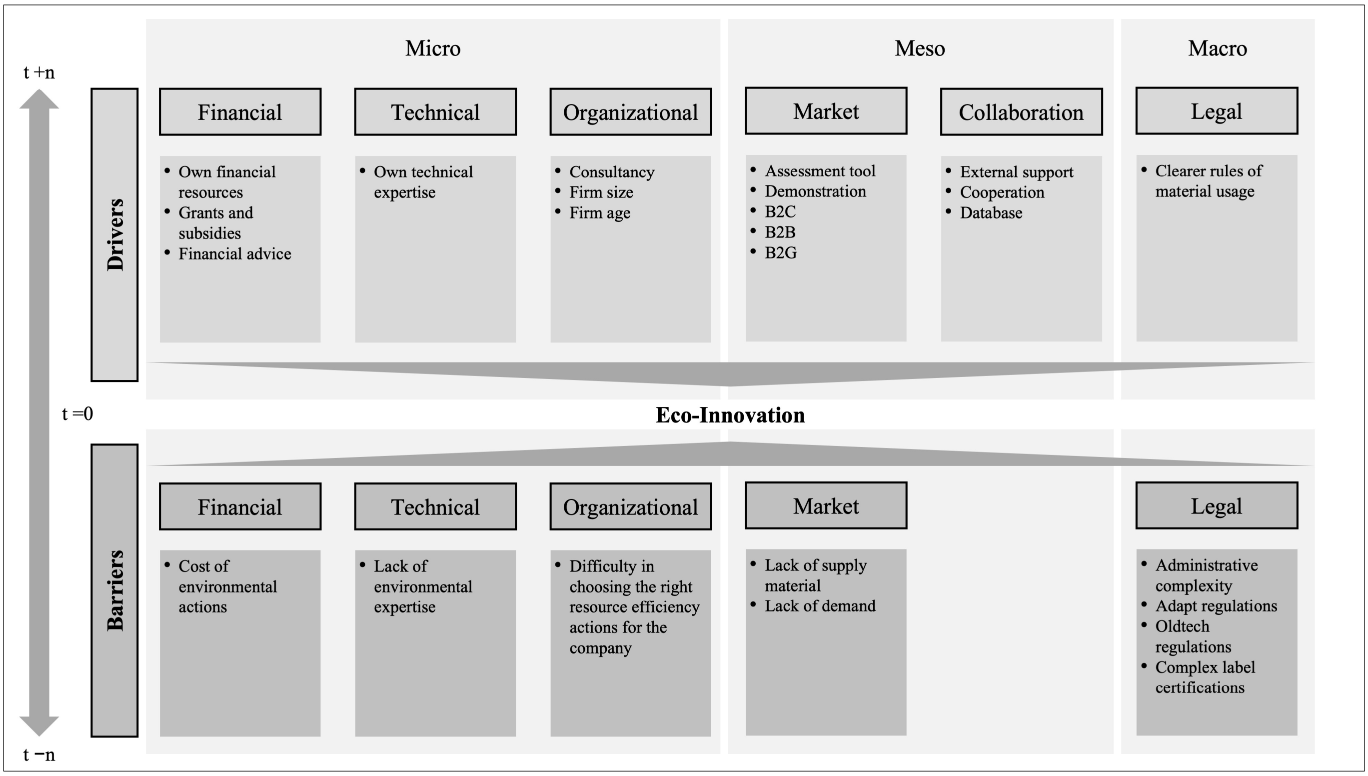

Figure 2. Operationalization of Eco-Innovation framework.

4.3. Empirical Strategy

Based on the binary nature of our dependent variable, we considered a class of binary response models such as the Logit and Probit models. According to [92],

$$\text{Prob}(\text{Y}_i = 1 \mid \text{X}_i) = \frac{\exp\left(X_i'\beta\right)}{1 + \exp\left(X_i'\beta\right)} = \Lambda(X_i'\beta)$$

where $\Lambda(.)$ denotes the logistic cumulative distribution function for a given vector of independent variables X_i and represents the Logit model such that

$$\lim_{X_i'\beta \to +\infty} \text{Prob}(\text{Y}_i = 1|\text{X}_i) = 1; \lim_{X_i'\beta \to -\infty} \text{Prob}(\text{Y}_i = 1|\text{X}_i) = 0$$

Similarly,

$$\text{Prob}(\text{Y}_i = 1 \mid \text{X}_i) = \int_{-\infty}^{X_i'\beta} \phi(t)dt = \Phi(X_i'\beta)$$

where $\Phi(.)$ denotes the standard normal distribution function for a given vector of independent variables X_i and represents the Probit model.

For the applied purposes, a natural question is which distribution to use. The logistics distribution is similar to the normal distribution except that the prior has heavier tails. The prediction probabilities are similar except when very few positive (Y = 1) or negative responses (Y = 0) are included. Theoretically, the choice between the two models remains unresolved [92]. However, for practical purposes, the choice between the two models is inconsequential unless further model prediction criteria suggest otherwise. Based on this, we estimated both models and performed a comparative analysis on the model fit, the results of which show strong support for the Logit model over the Probit model. These results are presented in Table S4 in our Supplementary File.

Finally, to supplement our conceptual classification, we used a Poisson regression model for count data, which is well-suited to non-negative outcomes:

$$\mathrm{Prob}(\mathrm{Y_i} = \mathrm{y_i} |\, \mathrm{X_i}) = \frac{\exp(-\lambda_\mathrm{i})\lambda_\mathrm{i}^{\mathrm{y_i}}}{\mathrm{y_i}!}$$

where $\mathrm{y_i}$ represents observed event counts, and λ_i denotes $\exp(\mathrm{X_i'}\beta)$, the predicted average number of actions taken by the firms, conditional on the independent variables.

For the convenience of interpreting regression coefficients and to provide comparability across the models, we estimated Average Marginal Effects (AMEs) post hoc. AMEs for an independent variable (e.g., d) calculate average differences between the presence of its effect (d = 1) versus the absence of its effect (d = 0), at each observation $x_{i(\mathrm{d})}$:

$$\text{Marginal effect} = \frac{1}{N}\sum_{i=1}^{N} \mathrm{Prob}\left[\mathrm{Y} = 1 \,\middle|\, x_{i(\mathrm{d})}, \mathrm{d} = 1\right] - \mathrm{Prob}\left[\mathrm{Y} = 1 \,\middle|\, x_{i(\mathrm{d})}, \mathrm{d} = 0\right]$$

AMEs imply that a one-unit change in the independent variable (in our case, discrete: 0 to 1) results in (AME $\times$ 100) % points on the probability of the dependent variable. A positive marginal effect implies that, from base level 0 to change level 1 in the independent variable, the probability of the dependent variable increases in EI. For example, in Table 3, which presents our results for the drivers' model, one of the drivers, COOPERATION, has a marginal effect of 0.129 (in column 2). This can be interpreted as a one-unit change in COOPERATION (a discrete change: from 0 = organizations that do not cooperate to 1 = organizations that do cooperate), increasing the probability of the dependent variable by 12.9%. For the Poisson model, the interpretation differs; AMEs capture the change in the expected number of actions in the EI as a dependent variable. This is implied relative to the sample mean of the dependent variable. For example, in Table 3, the AME of COOPERATION is 0.706 (in column 3). In absolute terms, this implies an increase of approximately 0.7 EI actions. Relative to the sample mean (3.706), this corresponds to an increase of 19% EI actions measured using the EI Breadth variable.

4.4. Model Specifications

Model specifications are assessed using standardized tests such as the Link, Log-likelihood ratio (LR), Hosmer–Lemeshow goodness-of-fit tests and Receiver Operating Characteristic (ROC) and Area Under the Curve (AUC) analyses (see, e.g., [93]). The Link test evaluates potential omitted variables and the functional relationship between the independent and dependent variables. The LR test compares restricted and full-specification models under the assumption of nested models, and the Hosmer–Lemeshow test assesses overall model fit. ROC AUC analysis assesses the model's discriminative power between positive (1 s) and negative (0 s) outcomes. There are known limitations of these diagnostics. For example, the Link test may detect misspecification issues but fail to acknowledge whether these misspecifications arise from missing non-linear linkages or missing jointly determined effects. Moreover, there are limited alternative Link functions [93]. Therefore, misspecification is left unaddressed, leading to a trial-and-error approach that undermines the theoretically grounded specification. Similarly, the Link and Hosmer–Lemeshow goodness-of-fit tests have been found to be sensitive to large sample sizes [94]. We present our model specification strategy in Table S5 in the Supplementary File. To ensure theoretical and empirical robustness, we report both models for which diagnostics indicate potential misspecification and those that pass all tests. Relying solely on empirical indications from such tests, at the expense of theoretically grounded baseline specifications, may lead to model misspecification. Overall, the driver and barrier models show mixed but generally

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supportive evidence for their specification. The Link test indicates that the predicted values are consistently significant, but the squared term becomes insignificant only after excluding the financial resource variable from the driver model and including relevant interaction terms in the barrier model. Similarly, with this specification, the Hosmer–Lemeshow test presents its limitations with large samples and marginally rejects the null hypothesis of good calibration. Nevertheless, the LR test and ROC AUC values consistently indicate the models' good discriminatory power. Altogether, these results suggest that, despite individual indications of misspecification due to testing limitations, our models are reasonably well specified. For comparative transparency, none of the variables exhibit radical changes in their magnitude, direction, or statistical significance, except for firm age. Perhaps, in the absence of access to a firm's own financial resources, firm size mediates this effect, implying that the larger the firm, the more likely it is to have access to financial resources. Furthermore, none of the variables show noticeable shifts from the top to the lower ranks, indicating a degree of stability across the model specification, as well as the measurement of the dependent variable.

Following [92,95] we also checked for the appropriateness of the Poisson model for its underlying assumption of 'equidispersion'. Under this assumption, the conditional variance equals the conditional mean. Violation of this assumption may cause over- or under-dispersion, potentially leading to biased standard errors and less reliable inferences. To test this, we calculated the dispersion ratio using the Pearson chi-square statistic and the residual degrees of freedom. The resulting dispersion ratios were 0.98 and 1.04 for the driver and barrier model, respectively. This indicated no substantial evidence of deviation from this assumption. In the case of minimum deviation from this assumption, usage of robust standard errors is advised in the literature [95]. As an additional safeguard, all Poisson models were estimated using country-clustered robust standard errors, which provide account for potential heteroskedasticity and within-country dependence. In addition, we acknowledge that our model is susceptible to reverse causality and potentially suffers from broader endogeneity concerns. Given the use of secondary data focused on EI, there are limitations regarding the identification of a relevant instrumental variable that meets the exclusion criteria. In light of these limitations, we suggest that our results should be interpreted as associative, with caution regarding directionality, but we deem them sufficient for the purposes of a conceptual classification and framework.

4.5. Moderation Analysis

To uncover the potential meso-level adhesive role connecting the macro- and micro-levels, we examined the interplay among the classified drivers using moderation analysis. Following the authors of [96], moderation in linear models is not comparable to that in non-linear models. Their work illustrates that the cross-partial derivative of the moderation term in a linear model is not the same as in non-linear models (such as the Logit model). Therefore, declaring moderation merely on the basis of the statistical significance of the moderation term is misleading and incomplete. Therefore, to check for moderation effects, we first estimated Logit coefficients and assessed whether the difference-in-differences in predicted probabilities for the identified moderator is also statistically significant. Using difference-in-differences, we captured the effect of a micro- or macro-level variable (X) when the meso-level moderator (Z) equals 1 or 0. A positive estimate indicates that the meso-level variable amplifies the effect of micro- or macro-level variables, whereas a negative estimate indicates that it dampens the effect.

5. Results

5.1. Drivers

Descriptive statistics are presented in Table 2, which shows that EI actions are above average, with almost 71% diffusion, and on average, organizations implement 4 EI actions. At the micro-level, firms primarily rely on their financial resources (financial category) at almost 68%. This is followed by reliance on grants and subsidies at almost 44%. Similarly, 54% of firms build their own technical expertise (technical category). At the meso-level, an active effort (market category) to learn about new technologies or processes is observed, and better possibilities for cooperation (collaboration category) for EI are mentioned by more than a quarter of firms. The sampled firms mainly sell directly to other businesses (75%) and customers (60%), while almost 29% also sell to public administrations. Lastly, at the macro-level, 19% of firms under the legal category also state that clearer rules on the use of secondary raw materials would drive the adoption of EI. The estimation of the driver model's correlation matrix showed no multicollinearity issues, as confirmed with a formal Variance Inflation Factor (VIF) test. The correlation matrix and VIF results are presented in Table S2 in the attached Supplementary File.

Table 2. Descriptive statistics.

Variable	Mean (SD) [a] (N = 10,896)
EI	0.704 (0.456)
EI Breadth [b]	3.706 (2.150)
Drivers	
Micro-Level Financial Category	
Financial Resources	0.679 (0.467)
Grant Subsidies	0.440 (0.496)
Financial Advice	0.255 (0.436)
Micro-Level Technical Category	
Technical Expertise	0.538 (0.499)
Micro-Level Organizational Category	
Consultancy	0.267 (0.442)
Firmsize	0.190 (0.427)
Firmage	0.820 (0.380)
Meso-Level Market Category	
Assessment Tool	0.165 (0.371)
Demonstration	0.261 (0.439)
B2C	0.595 (0.491)
B2B	0.756 (0.429)
B2G	0.287 (0.452)
Meso-Level Collaboration Category	
External Support	0.258 (0.437)
Database	0.172 (0.378)
Cooperation	0.277 (0.447)
Macro-Level Legal Category	
Reuse Rules	0.189 (0.392)
Barriers	
Micro-Level Financial Category	
Env Cost	0.279 (0.448)
Micro-Level Technical Category	

Table 2. *Cont.*

Variable	Mean (SD) [a] (N = 10,896)
Lacking Envexp	0.217 (0.412)
Micro-Level Organizational Category	
Difficulty Actionchoice	0.209 (0.407)
Meso-Level Market Category	
Lacking Supplymater	0.252 (0.434)
Lacking Demand	0.192 (0.394)
Macro-Level Legal Category	
Admin Complex	0.335 (0.472)
Adpt Regulations	0.209 (0.406)
Oldtech Regulations	0.193 (0.394)
Complex Label Cert	0.201 (0.401)
Manu	0.198 (0.398)
Retail	0.282 (0.450)
Serv	0.296 (0.457)
Ind	0.224 (0.417)

[a] Standard deviations in parentheses. All variables (except EI Breadth) have max value = 1 and min value = 0. [b] EI Breadth is a count variable with max value = 8 and min value = 0.

Following the framework, Table 3 presents the AMEs based on the Logit and Poisson models. The estimated coefficients of the models can be found in Table S6 in the Supplementary File. All drivers were statistically significant, but varied in their effect sizes. In addition, Poisson regression affirmatively indicates strong consistency and robustness based on the alternative functional form and dependent variable. The Poisson model also confirms that the average number of EI actions is positively associated with the drivers, similarly to the increase in likelihood when adopting more EI actions in the Logit model.

Table 3. Marginal effects—drivers.

	(1)	(2)	(3)
Variables	**Logit Marginal Effects**	**Logit Robust Marginal Effects**	**Poisson Marginal Effects**
Micro-Level Financial Category			
Financial Resources	0.180 ***		1.219 ***
	(0.00964)		(0.109)
Grant Subsidies	0.0826 ***	0.0975 ***	0.591 ***
	(0.00987)	(0.0105)	(0.0663)
Financial Advice	0.0755 ***	0.0892 ***	0.508 ***
	(0.00888)	(0.00880)	(0.0556)
Micro-Level Technical Category			
Technical Expertise	0.147 ***	0.130 ***	0.791 ***
	(0.0109)	(0.0118)	(0.0738)
Micro-Level Organizational Category			
Consultancy	0.0695 ***	0.0870 ***	0.454 ***
	(0.00941)	(0.00966)	(0.0626)
Firmsize	0.0423 ***	0.0534 ***	0.261 ***
	(0.00880)	(0.00908)	(0.0369)
Firmage	0.0114	0.0196 *	0.0999 *
	(0.0107)	(0.0112)	(0.0565)
Meso-Level Market Category			

Table 3. *Cont.*

	(1)	(2)	(3)
Variables	**Logit Marginal Effects**	**Logit Robust Marginal Effects**	**Poisson Marginal Effects**
Assessment Tool	0.0884 ***	0.103 ***	0.557 ***
	(0.0122)	(0.0135)	(0.0753)
Demonstration	0.0845 ***	0.102 ***	0.547 ***
	(0.00723)	(0.00738)	(0.0575)
B2C	0.0199 **	0.0244 **	0.130 ***
	(0.00927)	(0.00991)	(0.0424)
B2B	0.00429	0.00781	0.0223
	(0.0103)	(0.0107)	(0.0426)
B2G	0.0266 ***	0.0286 ***	0.0991 **
	(0.0103)	(0.0102)	(0.0431)
Meso-Level Collaboration Category			
External Support	0.151 ***	0.107 ***	0.685 ***
	(0.0118)	(0.0108)	(0.0528)
Database	0.0900 ***	0.107 ***	0.596 ***
	(0.0113)	(0.0124)	(0.0779)
Cooperation	0.109 ***	0.129 ***	0.706 ***
	(0.0121)	(0.0121)	(0.0677)
Macro-Level Legal Category			
Reuse Rules	0.106 ***	0.127 ***	0.700 ***
	(0.0120)	(0.0123)	(0.0660)
Manu	0.0599 ***	0.0742 ***	0.312 ***
	(0.0117)	(0.0124)	(0.0674)
Retail	0.00429	0.0122	0.0118
	(0.0115)	(0.0127)	(0.0573)
Serv	−0.0146 *	−0.0110	−0.157 ***
	(0.00757)	(0.00882)	(0.0435)
o.IND	-	-	
Observations	10,895	10,895	10,895
Country FE	YES	YES	YES

Country-clustered standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Regarding the micro-level, all three categories (financial, technical, and organizational) were found to be positively associated with EI actions. A firm's own financial resources have the largest marginal effect on EI actions, which is in agreement with previous empirical evidence [62]. The results show that firm-based technical know-how (technical category)—after financial resources—has the largest marginal effects on EI. To financially support basic and applied collaboration, government grant subsidies and financial advice for identifying such funding and investment opportunities are also statistically significant drivers in the financial category. Regarding the organizational category, building on the EI's risk and uncertainty perceptions, large and established firms are expected to take on such risks. The variables of firm size and age, as indicated by their statistical significance, show these implications.

Furthermore, EI is influenced by the market and collaboration categories at the meso-level, where inter-sectoral possibilities for cooperation amongst firms are one of the most important drivers in the model (collaboration category) and have the largest marginal effect. Despite their impactful and established roles in the market, perhaps due to incomplete information and inherent appropriation uncertainty about EI, external support and consultancy (organizational category) are also statistically significant drivers (as later confirmed via moderation analysis). The collaboration category further shows that the creation of a database containing records of EI projects and their benefits may have a positive, inspiring impact. At the nexus of Science–Industry–Policy [97], it is highly likely that sharing basic research can be positively associated with EI across organizations. Similarly, drivers such as assessment tools and demonstrations can help clarify the EI market competition landscape, underscoring the importance of the market category. These results are supported through the lens of evolutionary economics and dynamic resource capability theory, which dictates the consistent need for innovation to maintain natural selection in the industrial dynamics and competition [98]. Finally, the results also show that operating in B2C and B2G market segments is positively associated with EI. Interestingly, however, B2B segmentation plays no statistically significant role in driving EI. This can be best understood via stakeholder theory, which implies that EI adoption due to external pressure is likely to be heterogeneous across different market segments [79,99].

Finally, at the macro-level, in line with the vast literature on regulation, we see that clarity in rules and regulations on the use of secondary raw materials will positively influence EI (legal category). Section 6 further elaborates on these results and their implications.

5.2. Barriers

Regarding the descriptive statistics on barriers, Table 2 shows that there are no clear 'outliers' similar to those of financial resources in the driver model. At the macro-level, the expected regulatory administrative complexity in the legal category is the top barrier. At the meso-level, the lack of supply of materials, parts, products, or services accounts for almost 25% (market category). At the micro-level, firm-specific private environmental costs constitute another top-ranking barrier (financial category). In third place (accounting for 22%) is the lack of environmental expertise (technical category). The correlation matrix of barriers (see Supplementary Table S3) and VIF test showed no strong correlations, indicating that multicollinearity is not an issue.

Table 4 presents the marginal effects for barriers, and the model coefficients can be found in Table S7 in the Supplementary File. Based on the somewhat expected implications of the partial dynamic framing of the barrier question, all barriers are positive contributors to increased EI actions. These positive associations suggest that despite the confrontation of the barriers, EI has taken place. Therefore, firms that engage in EI are more likely to report barriers. In the joint effect of barriers, some interaction terms have negative signs and are statistically significant, indicating a negative combined impact on organizations. Once again, the Poisson model serves its purpose by providing strong supplementary consistency and robustness.

Table 4. Marginal effects—barriers.

	(1)	(2)	(3)
Variables	**Logit Marginal Effects**	**Logit Robust Marginal Effects**	**Poisson Marginal Effects**
Micro-Level Financial Category			
Env Cost	0.118 *** (0.0116)	0.147 *** (0.0151)	0.226 *** (0.0277)
Micro-Level Technical Category			
Lacking Envexp	0.0866 *** (0.0125)	0.115 *** (0.0217)	0.146 *** (0.0293)
Micro-Level Organizational Category			

Table 4. *Cont.*

	(1)	(2)	(3)
Variables	**Logit Marginal Effects**	**Logit Robust Marginal Effects**	**Poisson Marginal Effects**
Diff Actionchoice	0.0806 ***	0.112 ***	0.129 ***
	(0.0128)	(0.0167)	(0.0220)
Meso-Level Market Category			
Lacking Supplymater	0.0931 ***	0.118 ***	0.187 ***
	(0.0142)	(0.0164)	(0.0210)
Lacking Demand	0.0699 ***	0.0911 ***	0.0975 ***
	(0.0124)	(0.0183)	(0.0273)
Macro-Level Legal Category			
Admin Complex	0.0793 ***	0.102 ***	0.202 ***
	(0.00848)	(0.0164)	(0.0284)
Adpt Regulations	0.0243 *	0.0357 *	0.0590 **
	(0.0139)	(0.0197)	(0.0242)
Oldtech Regulations	0.0551 ***	0.0598 ***	0.0777 ***
	(0.0108)	(0.0110)	(0.0102)
Complex Label Cert	0.0884 ***	0.161 ***	0.202 ***
	(0.0128)	(0.0230)	(0.0338)
Firmsize	0.0749 ***	0.0717 ***	0.115 ***
	(0.00904)	(0.00897)	(0.0122)
Firmage	0.0150	0.0138	0.0335 **
	(0.0106)	(0.0106)	(0.0153)
Manu	0.0878 ***	0.0854 ***	0.120 ***
	(0.0138)	(0.0135)	(0.0206)
Retail	0.0130	0.0129	0.0138
	(0.0138)	(0.0136)	(0.0178)
Serv	−0.00772	−0.00703	−0.0283 **
	(0.00921)	(0.00912)	(0.0137)
o.IND	-	-	-
B2C	0.0329 ***	0.0327 ***	0.0511 ***
	(0.0105)	(0.0105)	(0.0126)
B2B	0.0265 **	0.0268 **	0.0398 ***
	(0.0112)	(0.0111)	(0.0138)
B2G	0.0370 ***	0.0375 ***	0.0478 ***
	(0.0107)	(0.0105)	(0.0110)
Observations	10,895	10,895	10,895
Country FE	YES	YES	YES
Interactions		YES	YES

Country-clustered standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

The results of the barrier model indicate the competing negative association of the macro-level legal category and micro-level cost constraints. Also identified through the channels of Porter competitive advantages and firm-level rationality, the models show that the macro-level legal complexity in label and certification, administrative processing, and micro-level environmental costing are the barriers that were confronted in pursuit of EI. The barrier of the complexity of environmental labeling and certification is not surprising, as desirable commercial use of such labels and certifications follows strict, third-party-verified, and consistently evolving criteria in the EU [100]. Other regulatory barriers, such as administrative complexity proxying for bureaucratic red tape, are also statistically significant. The high costs of environmental actions push organizations to adopt more of them. The cost variable is highly statistically significant and has the largest marginal effect. This can be explained through the relative assessment of higher costs incurred in the absence of such environmental actions, for example, loss of market share and, most importantly, inefficient resource optimization (such as energy). At the meso-level, market forces (supply and demand) act as statistically significant barriers. Due to the unavailability of required materials, parts, products, or services, firms have still innovated around it. Resistance would have been overcome by sourcing alternative supply materials, leading to EI. Similarly, the lack of demand for certain EI actions over time is expected to increase as climate change-related awareness has recently penetrated consumerism. Climate consciousness is becoming a universal consumer value, and organizations are learning to abide by it. Also, several apocalyptic natural disasters (e.g., flash floods, wildfires) have occurred across the globe, thereby increasing the sense of urgency and decreasing the "psychological distance" [101]. At the micro-level, in the technical category, the lack of warranted environmental expertise is also a barrier, with high statistical significance. A firm, in the absence of such skills, may have relied on external support and cooperation over time to overcome such barriers. The results also show that firms are unable to make suitable decisions to become more environmentally innovative. This highlights a firm's behavior in the face of dual market failures. However, policy intervention and market competition could be potential reasons for overcoming this micro-level organizational inertia over time.

In Figure 3, we summarize our results.

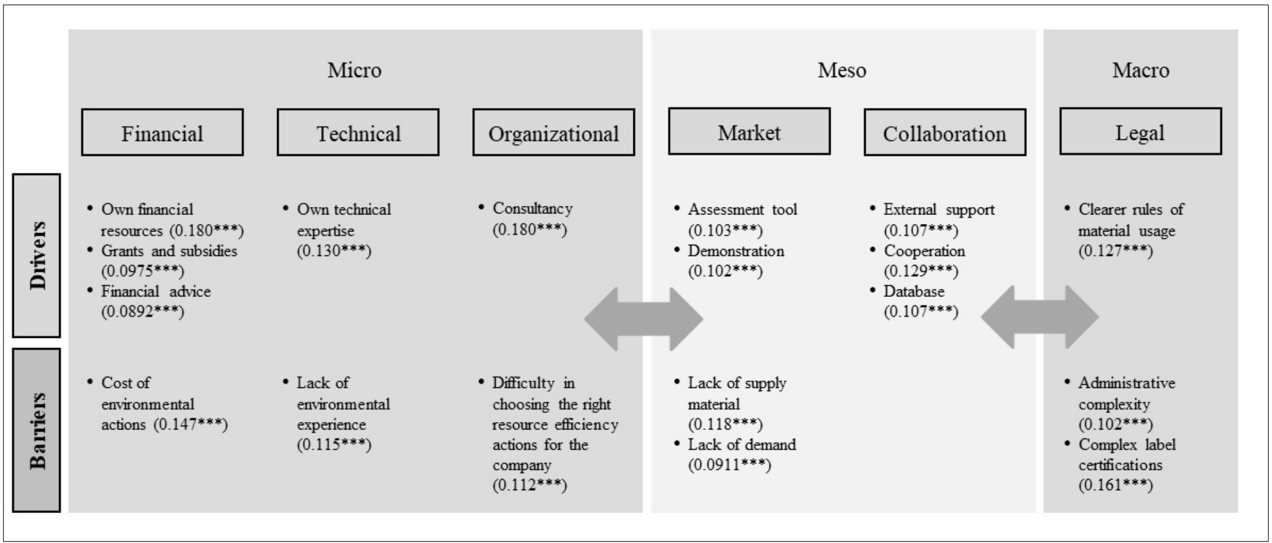

Figure 3. Summary of results; *** $p < 0.01$.

5.3. Moderation

To empirically elaborate on the meso-level interplay and identify potential policy actions, we conducted further moderation and interaction analyses between meso-level drivers and the macro- and micro-levels. We present the marginal effects of these results in Table 5, and the estimated coefficients in Table S8 in the Supplementary File.

Based on the reported results, the interplay reveals highly crucial collaborative organizational strategies that are conditional on organizational characteristics (micro) and are reinforced by institutional settings (macro). While the main effects of the identified drivers are positive and statistically significant for EI, in our moderation analysis, these effects might be dampened or amplified. Essentially, large organizations that rely on their own financial resources and technical expertise benefit less from meso-level assessment tool development, demonstrative exhibitions, and, most importantly, external support. Therefore, these meso-level variables are relatively strengthening smaller financially and technical expertise-constrained organizations. Similarly, database development at the meso-level that allows the study of case studies of organizational EI is in demand among financially constrained firms. This highlights the minimization of innovation costs due to knowledge spillovers. However, this database development amplifies firm size effects, implying that relatively larger firms better integrate the advantages of such a database.

Table 5. Marginal effects—moderation analysis.

	Full Driver Model and Each Variable Interaction [a,b]	**Full Driver Model and All Interactions** [c]
Variables	**(1) Marginal Effects**	**(2) Marginal Effects**
Dampening Effects		
Assessment Tool × Firmsize	−0.0495 * (0.0281)	−0.0466 * (0.0277)
Demonstration × Financial Res.	−0.0420 ** (0.0166)	−0.0316 * (0.0179)
External Sup. × Financial Res.	−0.138 *** (0.0203)	−0.137 *** (0.0202)
External Sup. × Technical Exp.	−0.134 *** (0.0137)	−0.133 *** (0.0139)
External Sup. × Firmsize	−0.0289 ** (0.0135)	−0.0381 *** (0.0130)
Database × Financial Res.	−0.0345 * (0.0178)	−0.0289 * (0.0171)
Cooperation × Technical Exp.	−0.0320 ** (0.0146)	−0.0249 (0.0154)
Amplifying Effects		
Database × Firmsize	0.0650 ** (0.0260)	0.0676 *** (0.0239)
B2C × Reuse Rules	0.0466 ** (0.0211)	0.0328 * (0.0198)
B2G × Firmage	0.0376 ** (0.0186)	0.0387 ** (0.0179)
Cooperation × Consultancy	0.0636 *** (0.0207)	0.0633 *** (0.0197)
Observations	10,895	10,895
Country FE	YES	YES

Country-clustered standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. [a] Based on the driver model, the table reports only moderation effects that show a statistically significant effect in both specifications [b] and [c]. Final inclusion is based on statistically significant differences in predicted probabilities, ensuring that reported effects show moderation in a non-linear setting, as highlighted in the Methods Section. [b] This specification is derived from specifications that use the driver model and the interaction between a single meso-level variable (e.g., assessment tool) and macro- and micro- variables. [c] The full model extends specification [b] by including all interactions simultaneously.

At the sector level, regulatory clarity on the usage of reuse material benefits consumer-facing firms (B2C) in adopting EI actions; perhaps the demand of sustainable goods is fostered by such regulations (regarding, e.g., recycled plastics and textiles). Similarly, relatively experienced public-sector-facing (B2G) firms leverage their experience-based capacity and compliance capability to increase EI actions.

Finally, similarly to database development, the cooperation variable is also context-specific. SMEs lacking technical expertise rely on cooperation and enable external support via consultancy. Therefore, cooperation bridges lacking technical expertise responsible for the staggering gap between a firm's willingness and ability to achieve green transition in EU SMEs.

6. Discussion

This study made a significant attempt to fill the outlined research gaps and open new avenues worth discussing. First, the proposed theoretical framework contributes to the literature and adds incremental strategic value to organizations seeking to achieve their EI objectives. By combining the theoretical argument of the Porter hypothesis and social network theory, the proposed framework enriches and deepens our fundamental understanding by identifying and consequently integrating crucial unique variables. Based on theoretical and empirical arguments, the framework shows that, on the one hand, there are several drivers at the meso- and micro-level. On the other hand, half of the barriers are located at the macro-level. Each individual driver and barrier—whether financial, organizational, or regulatory—demonstrates a measurable influence on EI activities. The results indicate that drivers and barriers to EI operate distinctly across the micro-, meso-, and macro-levels, yet their significance is also found to be influenced by their interconnection [15,34]. Our findings suggest that EI emerges from an intricate web of various factors rather than from a singular predictable mechanism, indicating that cautious interpretation is warranted, recognizing both the independent and systemic nature of the identified drivers and barriers.

Second, and most notably, drawing on social network theory, this paper highlights collaboration at the meso-level as a particularly promising dimension for advancing research on EI [24]. By explicitly incorporating the meso-level, this study proposes a novel framework that underscores the critical role of technological and organizational knowledge transfer in supporting EI. Moderation results show that organizations with limited financial or technical resources often compensate through collaborative networks at the meso-level. These results reflect the literature on SMEs-related constraints that motivate collaboration due to differences in size, absorptive capacities, managerial skills, access to resources, and the ability to interact with external partners, thereby reducing the cost of innovation and achieving organizational EI [24,64,102]. Theoretically, this contributes to social network theory, which argues that organizations jointly bundle their resources to achieve innovation. Smaller firms showcase the traditional "David versus Goliath" narrative with regard to EI through their strategic configuration of networks, alliances, and sectoral institutions to compensate for their limited internal or organizational resources [103]. For instance, development and institutionalization databases tend to amplify firm-size effects, reinforcing the advantage of relatively larger firms in accessing, interpreting, and strategically exploiting the underlying information. Overall, the proposed framework emerges as a tool showing that between the two poles of the macro- and micro-levels, the unique meso-level acts as connecting adhesive [104]. The novel dynamics of collaboration are highlighted with the distinctive inclusion of market-scanning variables, such as assessment tools, database development, and demonstrative exhibition sites. Third, drawing on stakeholder theory, the evidence suggests that the relationship between meso-level market orientation and EI is contingent on the salience and structure of external stakeholder pressures [79,99]. B2B firms appear to show insignificant association with EI, likely because their stakeholder environment tends to be characterized by relative cost minimization, reliability, and compliance-based actions compared to sustainability preference and reputational damages, which do not necessarily create strong or similar sustainability demands. By contrast, B2C firms are more likely to exhibit stronger EI when clear rules for product reuse are in place, since transparent institutional expectations can strengthen consumer-facing legitimacy pressures and encourage innovation aligned with circular practices. This provides recommendations for previous studies finding B2C and B2B pressures to be insignificant [99]. Similarly, B2G firms tend to engage more actively in EI when they are older and more experienced, as organizational age may enhance their capability to interpret public sector expectations and respond to the more demanding normative and regulatory requirements associated with government stakeholders. However, this pattern risks excluding less-experienced and smaller organizations, thereby reinforcing a structural bias toward firms already embedded in public sector networks. Theoretically, market effects often operate indirectly through, e.g., competitive dynamics or latent consumer preferences, becoming overshadowed by more proximal drivers such as regulatory mandates or cost-saving potentials [25]. EI frequently yields long-term benefits whose market value remains opaque in the short term, diluting observable firm-level responses. Moreover, customers may be unwilling to pay a substantial premium for sustainable solutions, limiting direct market incentives [29,38]. Firms may also hesitate to invest when innovations are susceptible to knowledge spillovers—where competitors can imitate them without cost—and generate environmental externalities that benefit society broadly rather than the innovator exclusively [24,33]. Consequently, such investments appear risky, uncertain, and characterized by inadequate appropriation mechanisms, undermining their commercial viability. Besides theoretical arguments, reasons can be found methodologically. Measurement imprecision may arise when market variables capture general conditions rather than targeted green demand signals. Multicollinearity with related constructs, such as competition intensity or anticipated demand, can further obscure the market.

Fourth, the ambiguous nature of certain determinants—functioning as both drivers and barriers under varying contextual conditions—illustrates the inherent complexity and non-linearity of EI processes. Our insights prompt the adequacy of linear cause–effect models and call for more integrative frameworks that reflect the coexistence of feedback loops, paradoxical effects, and the time-varying role of determinants. The findings reveal that certain factors traditionally perceived as barriers—such as regulatory pressures—may, over time, evolve into drivers once firms adapt their capabilities and strategically exploit these external demands as opportunities for transformation. In the context of EI, specifically, the notion of a positive barrier refers to regulatory or legal constraints that initially impose limitations on firms but ultimately stimulate adaptive and innovative responses with long-term benefits. Hence, positive barriers embody a paradoxical dynamic—restrictive in their immediate effect but enabling in their long-term impact. Thus, managerial myopia is highlighted as a barrier to EI [105]. These ambiguous positive barriers are best explained through the Porter hypothesis, but with a few important caveats. A primary empirical concern is potential selection bias, whereby firms that report EI may also be more likely to encounter, recognize, and report the implementation or awareness of such difficulties. In such cases, positive coefficients may reflect higher engagement rather than the absence of such barriers. To assess this, cross-tabulations between barriers and EI revealed that this concern is partially responsible for such results. Only 7% to 17% of reported barriers have been observed among organizations that did not successfully conduct EI. To show the frequency of reported barriers, Figure S1 in the Supplementary File provides a graphical illustration. Overall, the results suggest that specified barriers, due to their partial dynamic framing, do not fully prohibit actions (negative impact) but rather act as sources of resistance that firms must navigate while engaging with EI.

7. Implications

7.1. Theoretical Implications

From our work, several implications can be deduced. Theoretically, the findings of this study confirm that the identified drivers and barriers operate across the three analytical levels considered. This supports the view that EI can be most effectively understood through an integrated conceptual framework that combines multiple theoretical perspectives. With this study, it is possible to suggest that our conceptually myopic understanding of EI, with regard to meso-level factors, is a valid concern [34]. Future research may advance the field by investigating across levels and categories to understand EI, employing a hierarchical empirical design that is currently lacking in our study. While micro-level factors are important, they are aggregated and embedded into institutions. Moreover, the transmission catalyst is the meso-level that fosters collaboration across and within sectors through demonstration sites, assessment tools, and databases. Therefore, the proposed framework necessitates

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further exploration with broadened, complex EI dynamics, especially when integrating the meso-level.

Despite this study's limitations of relying on narrowly focused secondary, EU-specific, and cross-sectional data, it offers a uniquely comprehensive empirical foundation for understanding EI among SMEs. The static nature of the data limits the ability to gain complete insights into temporal developments and causal dynamics. The narrow focus of the survey does not allow identification of an appropriate instrumental variable and leaves endogeneity concerns unaddressed. Moreover, the employed survey data is based on self-reported perceptions and experiences rather than on directly observed organizational behavior or externally verified measures. However, the scale and representativeness of the data provide plausible analytical depth. Drawing on a dataset covering nearly 11,000 SMEs across EU member states, this research captures diverse organizational settings and surroundings, allowing for a robust generalization of findings within the European context. Future longitudinal or comparative studies based on observed data could build on this groundwork to trace how EI patterns evolve over time and across different EU and other policy regimes.

7.2. Practical Implications

For practitioners, this paper provides an effective blueprint for organizational EI action, especially within the EU regulatory uniformity and its transition ambitions. Successful EI requires the strategic alignment of internal capabilities with external opportunities and pressures. Specifically, financial resources and technical know-how are important positive factors. While eco-labels and environmental costs due to administrative complexity are identified as barriers, they are crucial for overcoming organizational inertia and gaining a competitive advantage in the long run. Therefore, investments in such categories pay off in the end, as organizations become legally compliant, market-relevant, and ready to compete and collaborate. Organizations should conduct systematic assessments of their resource and capability profiles to identify strengths that can be leveraged and gaps that must be addressed. Capability development in areas such as environmental knowledge, technical expertise, and organizational learning to successfully integrate the advantages of available tools such as databases and assessment tools should be prioritized. Involvement in cooperative partnerships to consult with technology providers and research institutions and participation in demonstrative exhibitions provide access to capabilities and knowledge that complement internal resources.

Regarding policy, drawing on the underlying theory of this paper and the EI framework, "Porter-compatible" regulation—meaning stringent, predictable policy requirements—is especially effective in enabling innovation networks and clusters (e.g., green innovation ecosystems, public–private partnerships). Given the apparent importance of the financial dimension, policy should provide financial support mechanisms addressing capital barriers, particularly for SMEs and EI requiring substantial investments. Subsidies and risk-sharing mechanisms can improve the business case for EI and reduce financial barriers. Furthermore, knowledge infrastructure development through technology transfer mechanisms and innovation networks can address capability barriers. Public investment in demonstration projects and knowledge dissemination platforms creates public goods that benefit multiple organizations and accelerate EI diffusion.

In terms of actual policy design, integrated policy approaches combining regulatory, economic, and informational instruments have been proven to be more effective than single-instrument approaches [22,23]. Policy mixes that address multiple barriers simultaneously and create reinforcing incentives generate stronger innovation responses. Policies should account for contextual differences across market segments, industries, regions, and organizational types. One-size-fits-all approaches may be ineffective or even counterproductive. Tailored policy designs that reflect specific contexts while maintaining overall coherence and consistency provide optimal support for EI.

Tailored to market segmentation, customer-facing SMEs signify a need for regulatory certainty and policy intervention in reuse material markets to achieve circular supply chains. In the case of the EU, virgin plastics remain cheaper than recycled plastics, leading to the bankruptcy of organizations that have heavily invested in chemical recycling plants [106,107]. Moreover, the Supply Chain Due Diligence Act (in Germany [83]) may increase B2B firms' propensity for EI by intensifying regulatory scrutiny and stakeholder expectations across the supply chain. From a stakeholder perspective, it strengthens the relevance of environmental compliance as a strategic response rather than a purely legal obligation.

SMEs and new entrants remain at a structural disadvantage in fully leveraging knowledge-based datasets. For large firms, public and private databases may be most impactful as complementary tools that enhance existing R&D, strategic planning, and market-intelligence functions. For SMEs, targeted intermediary support—such as data-analytic advisory services or sector-specific data platforms—may be necessary to bridge competency gaps, hence ensuring that public investments in data ecosystems do not systematically reinforce existing inequalities in their capacity to innovate.

To counteract disadvantages of new firms in the public procurement market segment, innovation policies should combine the following complementary governance mechanisms: first, phased, SME-friendly public procurement strategies that gradually introduce stronger sustainability criteria instead of front-loading complex requirements; second, digital platforms that facilitate matchmaking, knowledge exchange, and demonstration projects between public procurers, smaller firms, and frontier innovators; and third, institutionalized round-table governance formats that bring together public authorities, SME representatives, intermediaries, and academia to systematically identify and remove barriers in the EI–B2G interface. Together, these mechanisms can transform the observed firm-level learning advantages into a more inclusive and dynamic ecosystem for EI, in which experience is diffused and not monopolized, and in which public-sector demand is systematically harnessed to support a broader range of innovators.

8. Conclusions

This paper reviews crucial themes and investigates the pathways of EI adoption in organizations. Building on the contemporary literature and its gaps, a comprehensive theoretical framework is introduced, considering the micro-, meso-, and macro-levels and six categories within these levels. Extensive empirical results complement the proposal of such a framework. Most key determinants show comparable marginal effects, indicating that different factors are essential to organizations and that a strategic mix of them is necessary. European SMEs possess various options, and each organization has a different path to EI. However, the factors at a given level or category can be somewhat ranked. More precisely, this study confirms the importance of financial resources, technical knowledge, cooperation, and its mechanics. Technical expertise allows firms to build on their knowledge and, combined with opportunities in consultancy supported by transparent market tools, to gain an even broader view of technical approaches. In terms of barriers, macro-level regulations are relevant. Considering the Porter hypothesis, this paper shows that barriers are ambiguous in partial dynamic settings and warrant further investigation. Nevertheless, environmental costs, complex labels, and certifications based on administrative complexity are resisting factors for EU SMEs to conduct EI actions. In particular, the importance of meso-level, grounded in social network theory, was identified based on its integration into the framework and the quantitative evidence indicating that a lack of financial resources or skills at the micro-level can be made up for through collaborative mechanisms.

For managers, our work underscores the need to strategically allocate resources toward participation in knowledge exchange through physical and digital platforms and support services, depending on firm size, financial resources, expertise, experience, and absorptive capacity. Policymakers exert both direct and indirect influences on EI. Directly, they shape EI through policy instruments in the financial, legal, and market domains, such as through subsidies, reuse and circularity regulations, and institutionalized public–private interactions via B2G relationships. Indirectly, they structure enabling environments by shaping spaces for collaboration, funding external support infrastructures (e.g., innovation agencies, advisory services), configuring access to and governance of databases, and promoting inter-organizational cooperation. However, this research calls for differentiated, multi-instrumental governance strategies that combine tailored financial support, simplified and phased procurement designs, and institutionalized collaborative forums, thereby aligning public sector, firm-level, and intermediary interests to systematically convert barriers into drivers of EI.

Supplementary Materials: The following supporting information can be downloaded at https://www.mdpi.com/article/10.3390/su18115542/s1, Table S1: Description of the variables; Table S2: Correlation matrix—driver model; Table S3: Correlation matrix—barrier model; Table S4: Model specification—Probit or Logit; Table S5: Model specification—diagnostics; Table S6: Logit and Poisson coefficients—driver model; Table S7: Logit and Poisson coefficients—barrier model; Table S8: Logit coefficients—moderation analysis; and Figure S1: Frequency of barriers reported.

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Abbreviations

The following abbreviations are used in this manuscript:

EI	Eco-Innovation
CE	Circular Economy
SMEs	Small and Medium-Sized Enterprises
EU	European Union

References

1. Russo, M.V.; Louche, C.; Wagner, M. A Solid Foundation But What Will Be Built on It? Reviews of the Management, Organizations, and Environmental Sustainability Field. *Organ. Environ.* **2024**, *37*, 119–132. [CrossRef]
2. Dagilienė, L.; Varaniūtė, V. Transitioning to a Circular Economy: Paradoxical Tensions of the Circular Business Model. *Organ. Environ.* **2023**, *36*, 559–589. [CrossRef]
3. United Nations Department of Economic and Social Affairs. The-Sustainable-Development-Goals-Report-2025, New York. Available online: https://unstats.un.org/sdgs/report/2025/The-Sustainable-Development-Goals-Report-2025.pdf (accessed on 13 April 2026).
4. European Commission. The European Green Deal Striving to Be the First Climate-Neutral Continent. 2024. Available online: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en (accessed on 1 May 2026).
5. European Commission. *2020 Circular Economy Action Plan International Aspects*; Publications Office of the European Union: Brussels, Belgium, 2020.
6. European Commission. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on "Innovation for a Sustainable Future—The Eco-Innovation Action Plan (Eco-AP). COM(2011) 899 Final. 2011; pp. 1–20. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52011DC0899 (accessed on 1 May 2026).
7. Di Bella, L.; Katsinis, A.; Lagüera-González, J.; Odenthal, L.; Hell, M.; Lozar, B. *Annual Report on European SMEs 2022/2023: SME Performance Review 2022/2023*; Publications Office of the European Union: Luxemburg, 2023.
8. Özbuğday, F.C.; Fındık, D.; Özcan, K.M.; Başçı, S. Resource efficiency investments and firm performance: Evidence from European SMEs. *J. Clean. Prod.* **2020**, *252*, 119824. [CrossRef]
9. Urbinati, A.; Franzò, S.; Chiaroni, D. Enablers and Barriers for Circular Business Models: An empirical analysis in the Italian automotive industry. *Sustain. Prod. Consum.* **2021**, *27*, 551–566. [CrossRef]
10. Dahlström, P.; Lööf, H.; Sjöholm, F.; Stephan, A. The EU's comparative advantage in the "clean-energy arms race". *Ann. Reg. Sci.* **2025**, *74*, 14. [CrossRef]
11. Draghi, M. The Draghi Report: The future of European Competitiveness—A Competitiveness Strategy for Europe. 2024. Available online: http://data.europa.eu/eli/dec/2011/833/oj (accessed on 1 May 2026).
12. Eurostat. Circular Economy Monitoring Framework. 2026. Available online: https://ec.europa.eu/eurostat/web/circular-economy/monitoring-framework (accessed on 1 May 2026).
13. Bending, T.; Delanote, J.; Dos Santos, I.; Gilson, N.; Guyot, N.; Harasztosi, P.; Kolev, A.; Martens, A.; Olejnik, T.; Schanz, J.; et al. *The State of Local Infrastructure Investment in Europe EIB Municipalities Survey 2022–2023*; European Investment Bank: Luxembourg, 2023.
14. Porter, M.E.; van der Linde, C. Toward a New Conception of the Environment-Competitiveness Relationship. *J. Econ. Perspect.* **1995**, *9*, 97–118. [CrossRef]
15. Díaz-García, C.; González-Moreno, A.; Sáez-Martíínez, F.J. Eco-innovation: Insights from a literature review. *Innov. Manag. Policy Pract.* **2015**, *17*, 6–23. [CrossRef]
16. Kemp, R.; Pearson, P. Final Report MEI Project about Measuring Eco-Innovation. 2007. Available online: https://lab.unu-merit.nl/wp-content/uploads/2021/05/Final-report-MEI-project-about-measuring-eco-innovation-1.pdf (accessed on 1 May 2026).
17. Kirchherr, J.; Reike, D.; Hekkert, M. Conceptualizing the circular economy: An analysis of 114 definitions. *Resour. Conserv. Recycl.* **2017**, *127*, 221–232. [CrossRef]
18. Kirchherr, J.; Yang, N.-H.N.; Schulze-Spüntrup, F.; Heerink, M.J.; Hartley, K. Conceptualizing the Circular Economy (Revisited): An Analysis of 221 Definitions. *Resour. Conserv. Recycl.* **2023**, *194*, 107001. [CrossRef]
19. Ormazabal, M.; Prieto-Sandoval, V.; Puga-Leal, R.; Jaca, C. Circular Economy in Spanish SMEs: Challenges and opportunities. *J. Clean. Prod.* **2018**, *185*, 157–167. [CrossRef]
20. Pérez, G.L.; Sánchez, I.M.G.; Gómez, J.L.Z. A systematic literature review and bibliometric analysis of eco-innovation on financial performance: Identifying barriers and drivers. *Bus. Strat. Environ.* **2023**, *33*, 1321–1340. [CrossRef]
21. Liu, Y.; Chen, X.; Zhang, W. Towards a Holistic Understanding of Green Innovation Adoption: A Systematic Review of Determinants, Barriers, and Outcomes. *J. Logist. Inform. Serv. Sci.* **2024**, *11*, 501–543. [CrossRef]
22. Kiefer, C.P.; González, P.D.R.; Carrillo-Hermosilla, J. Drivers and barriers of eco-innovation types for sustainable transitions: A quantitative perspective. *Bus. Strat. Environ.* **2018**, *28*, 155–172. [CrossRef]
23. del Río, P.; Carrillo-Hermosilla, J.; Könnölä, T. Policy Strategies to Promote Eco-Innovation. *J. Ind. Ecol.* **2010**, *14*, 541–557. [CrossRef]
24. Pereira, R.M.; MacLennan, M.L.F.; Tiago, E.F. Interorganizational cooperation and eco-innovation: A literature review. *Int. J. Innov. Sci.* **2020**, *12*, 477–493. [CrossRef]
25. Horbach, J. Determinants of environmental innovation—New evidence from German panel data sources. *Res. Policy* **2008**, *37*, 163–173. [CrossRef]

26. Horbach, J.; Rammer, C.; Rennings, K. Determinants of eco-innovations by type of environmental impact—The role of regulatory push/pull, technology push and market pull. *Ecol. Econ.* **2012**, *78*, 112–122. [CrossRef]
27. Rennings, K. Redefining innovation—Eco-innovation research and the contribution from ecological economics. *Ecol. Econ.* **2000**, *32*, 319–332. [CrossRef]
28. de Jesus, A.; Antunes, P.; Santos, R.; Mendonça, S. Eco-innovation in the transition to a circular economy: An analytical literature review. *J. Clean. Prod.* **2018**, *172*, 2999–3018. [CrossRef]
29. Schultz, F.C.; Reinhardt, R.J. Facilitating systemic eco-innovation to pave the way for a circular economy: A qualitative-empirical study on barriers and drivers in the European polyurethane industry. *J. Ind. Ecol.* **2022**, *26*, 1646–1675. [CrossRef]
30. Austin, A.; Alataş, S.; Agbonifi, D. Financing Eco-Innovation in an Emerging Economy: The Role of Internal Resources, External Support and Government in Turkish SMEs. *Sustain. Dev.* **2025**, *34*, 213–226. [CrossRef]
31. Kirchherr, J.; Urbinati, A.; Hartley, K. Circular economy: A new research field? *J. Ind. Ecol.* **2023**, *27*, 1239–1251. [CrossRef]
32. de Jesus, A.; Mendonça, S. Lost in Transition? Drivers and Barriers in the Eco-innovation Road to the Circular Economy. *Ecol. Econ.* **2018**, *145*, 75–89. [CrossRef]
33. Jaffe, A.B.; Newell, R.G.; Stavins, R.N. A tale of two market failures: Technology and environmental policy. *Ecol. Econ.* **2005**, *54*, 164–174. [CrossRef]
34. Chatzinikolaou, D.; Kubus, R. Macro–Meso–Micro: An Integrative Framework for Evolutionary Economics and Sustainable Transitions. *Sustainability* **2025**, *17*, 9480. [CrossRef]
35. Geels, F.W. Technological transitions as evolutionary reconfiguration processes: A multi-level perspective and a case-study. *Res. Policy* **2002**, *31*, 1257–1274. [CrossRef]
36. Kemp, R.; Schot, J.; Hoogma, R. Regime shifts to sustainability through processes of niche formation: The approach of strategic niche management. *Technol. Anal. Strat. Manag.* **1998**, *10*, 175–198. [CrossRef]
37. Castañer, X.; Oliveira, N. Collaboration, Coordination, and Cooperation Among Organizations: Establishing the Distinctive Meanings of These Terms Through a Systematic Literature Review. *J. Manag.* **2020**, *46*, 965–1001. [CrossRef]
38. Geissdoerfer, M.; Santa-Maria, T.; Kirchherr, J.; Pelzeter, C. Drivers and barriers for circular business model innovation. *Bus. Strat. Environ.* **2022**, *32*, 3814–3832. [CrossRef]
39. Takacs, F.; Brunner, D.; Frankenberger, K. Barriers to a circular economy in small- and medium-sized enterprises and their integration in a sustainable strategic management framework. *J. Clean. Prod.* **2022**, *362*, 132227. [CrossRef]
40. Cainelli, G.; D'Amato, A.; Mazzanti, M. Resource efficient eco-innovations for a circular economy: Evidence from EU firms. *Res. Policy* **2020**, *49*, 103827. [CrossRef]
41. Galvão, G.D.A.; Evans, S.; Ferrer, P.S.S.; de Carvalho, M.M. Circular business model: Breaking down barriers towards sustainable development. *Bus. Strat. Environ.* **2022**, *31*, 1504–1524. [CrossRef]
42. Pinkse, J.; Lüdeke-Freund, F.; Laasch, O.; Snihur, Y.; Bohnsack, R. The Organizational Dynamics of Business Models for Sustainability: Discursive and Cognitive Pathways for Change. *Organ. Environ.* **2023**, *36*, 211–227. [CrossRef]
43. Piila, N.; Sarja, M.; Onkila, T.; Mäkelä, M. Organisational Drivers and Challenges in Circular Economy Implementation: An Issue Life Cycle Approach. *Organ. Environ.* **2022**, *35*, 523–550. [CrossRef]
44. Lüdeke-Freund, F.; Froese, T.; Dembek, K.; Rosati, F.; Massa, L. What Makes a Business Model Sustainable? Activities, Design Themes, and Value Functions. *Organ. Environ.* **2024**, *37*, 194–220. [CrossRef]
45. Olesson, E.; Nenonen, S.; Newth, J. Enablers and Barriers: The Conflicting Role of Institutional Logics in Business Model Change for Sustainability. *Organ. Environ.* **2023**, *36*, 228–252. [CrossRef]
46. Passaro, R.; Quinto, I.; Scandurra, G.; Thomas, A. The drivers of eco-innovations in small and medium-sized enterprises: A systematic literature review and research directions. *Bus. Strategy Environ.* **2023**, *32*, 1432–1450. [CrossRef]
47. Peyravi, B.; Jakubavičius, A. Drivers in the Eco-Innovation Road to the Circular Economy: Organiational Capabilities and Exploitative Strategies. *Sustainability* **2022**, *14*, 10748. [CrossRef]
48. Bocken, N.M.; Geradts, T.H. Barriers and drivers to sustainable business model innovation: Organization design and dynamic capabilities. *Long Range Plan.* **2020**, *53*, 101950. [CrossRef]
49. Liao, Z.; Liu, Y. What drives environmental innovation? A meta-analysis. *Bus. Strat. Environ.* **2020**, *30*, 1852–1864. [CrossRef]
50. Diez-Martinez, I.; Peiro-Signes, A.; Segarra-Oña, M. The links between active cooperation and eco-innovation orientation of firms: A multi-analysis study. *Bus. Strat. Environ.* **2022**, *32*, 430–443. [CrossRef]
51. Ranta, V.; Aarikka-Stenroos, L.; Mäkinen, S.J. Creating value in the circular economy: A structured multiple-case analysis of business models. *J. Clean. Prod.* **2018**, *201*, 988–1000. [CrossRef]
52. Triguero, Á.; Cuerva, M.C.; Álvarez-Aledo, C. Environmental Innovation and Employment: Drivers and Synergies. *Sustainability* **2017**, *9*, 2057. [CrossRef]
53. Ferasso, M.; Beliaeva, T.; Kraus, S.; Clauss, T.; Ribeiro-Soriano, D. Circular economy business models: The state of research and avenues ahead. *Bus. Strategy Environ.* **2020**, *29*, 3006–3024. [CrossRef]

54. Rizos, V.; Behrens, A.; Van Der Gaast, W.; Hofman, E.; Ioannou, A.; Kafyeke, T.; Flamos, A.; Rinaldi, R.; Papadelis, S.; Hirschnitz-Garbers, M.; et al. Implementation of Circular Economy Business Models by Small and Medium-Sized Enterprises (SMEs): Barriers and Enablers. *Sustainability* **2016**, *8*, 1212. [CrossRef]
55. Agyemang, M.; Kusi-Sarpong, S.; Khan, S.A.; Mani, V.; Rehman, S.T.; Kusi-Sarpong, H. Drivers and barriers to circular economy implementation: An explorative study in Pakistan's automobile industry. *Manag. Decis.* **2019**, *57*, 971–994. [CrossRef]
56. Hina, M.; Chauhan, C.; Kaur, P.; Kraus, S.; Dhir, A. Drivers and barriers of circular economy business models: Where we are now, and where we are heading. *J. Clean. Prod.* **2022**, *333*, 130049. [CrossRef]
57. Leyva-de la Hiz, D.I.; Hurtado-Torres, N.; Bermúdez-Edo, M. The Heterogeneity of Levels of Green Innovation by Firms in International Contexts: A Study Based on the Home-Country Institutional Profile. *Organ. Environ.* **2018**, *32*, 508–527. [CrossRef]
58. Chistov, V.; Aramburu, N.; Carrillo-Hermosilla, J. Open eco-innovation: A bibliometric review of emerging research. *J. Clean. Prod.* **2021**, *311*, 127627. [CrossRef]
59. Segarra-Blasco, A.; Teruel, M.; Tomàs-Porres, J. Circular economy and public policies: A dynamic analysis for European SMEs. *Bus. Strat. Environ.* **2024**, *33*, 3532–3549. [CrossRef]
60. Kirchherr, J.; Piscicelli, L.; Bour, R.; Kostense-Smit, E.; Muller, J.; Huibrechtse-Truijens, A.; Hekkert, M. Barriers to the Circular Economy: Evidence From the European Union (EU). *Ecol. Econ.* **2018**, *150*, 264–272. [CrossRef]
61. Marín-Vinuesa, L.M.; Scarpellini, S.; Portillo-Tarragona, P.; Moneva, J.M. The Impact of Eco-Innovation on Performance Through the Measurement of Financial Resources and Green Patents. *Organ. Environ.* **2018**, *33*, 285–310. [CrossRef]
62. Austin, A.; Rahman, I.U. A triple helix of market failures: Financing the 3Rs of the circular economy in European SMEs. *J. Clean. Prod.* **2022**, *361*, 132284. [CrossRef]
63. Kemp, R. Technology and the transition to environmental sustainability: The problem of technological regime shifts. *Futures* **1994**, *26*, 1023–1046. [CrossRef]
64. Audretsch, D.B.; Belitski, M.; Caiazza, R.; Phan, P. Collaboration strategies and SME innovation performance. *J. Bus. Res.* **2023**, *164*, 114018. [CrossRef]
65. Burt, R.S. Structural Holes and Good Ideas. *Am. J. Sociol.* **2004**, *110*, 349–399. [CrossRef]
66. Uzzi, B.; Spiro, J. Collaboration and Creativity: The Small World Problem. *Am. J. Sociol.* **2005**, *111*, 447–504. [CrossRef]
67. Kuhlmann, M.; Meuer, J.; Bening, C.R. Interorganizational Sensemaking of the Transition Toward a Circular Value Chain. *Organ. Environ.* **2023**, *36*, 411–441. [CrossRef]
68. de Abreu, M.C.S.; Ferreira, F.N.H.; Proença, J.F.; Ceglia, D. Collaboration in achieving sustainable solutions in the textile industry. *J. Bus. Ind. Mark.* **2020**, *36*, 1614–1626. [CrossRef]
69. Herczeg, G.; Akkerman, R.; Hauschild, M.Z. Supply chain collaboration in industrial symbiosis networks. *J. Clean. Prod.* **2018**, *171*, 1058–1067. [CrossRef]
70. Tardin, M.G.; Perin, M.G.; Simões, C.; Braga, L.D. Organizational Sustainability Orientation: A Review. *Organ. Environ.* **2024**, *37*, 298–324. [CrossRef]
71. Barros, M.V.; Salvador, R.; Prado, G.F.D.; de Francisco, A.C.; Piekarski, C.M. Circular economy as a driver to sustainable businesses. *Clean. Environ. Syst.* **2021**, *2*, 100006. [CrossRef]
72. Rocca, L.; Veneziani, M.; Carini, C. Mapping the diffusion of circular economy good practices: Success factors and sustainable challenges. *Bus. Strat. Environ.* **2022**, *32*, 2035–2048. [CrossRef]
73. Bag, S.; Dhamija, P.; Bryde, D.J.; Singh, R.K. Effect of eco-innovation on green supply chain management, circular economy capability, and performance of small and medium enterprises. *J. Bus. Res.* **2022**, *141*, 60–72. [CrossRef]
74. Howard, M.; Böhm, S.; Eatherley, D. Systems resilience and SME multilevel challenges: A place-based conceptualization of the circular economy. *J. Bus. Res.* **2022**, *145*, 757–768. [CrossRef]
75. Tyler, B.; Lahneman, B.; Beukel, K.; Cerrato, D.; Minciullo, M.; Spielmann, N.; Cruz, A.D. SME Managers' Perceptions of Competitive Pressure and the Adoption of Environmental Practices in Fragmented Industries: A Multi-Country Study in the Wine Industry. *Organ. Environ.* **2018**, *33*, 437–463. [CrossRef]
76. *ISO 14001:2026*; Environmental Management Systems. International Organization for Standardization: Geneva, Switzerland, 2026.
77. Bodas-Freitas, I.-M.; Corrocher, N. The use of external support and the benefits of the adoption of resource efficiency practices: An empirical analysis of european SMEs. *Energy Policy* **2019**, *132*, 75–82. [CrossRef]
78. Homrich, A.S.; Galvão, G.; Abadia, L.G.; Carvalho, M.M. The circular economy umbrella: Trends and gaps on integrating pathways. *J. Clean. Prod.* **2018**, *175*, 525–543. [CrossRef]
79. Kumar, V.; Rahman, Z.; Kazmi, A.A. Assessing the Influence of Stakeholders on Sustainability Marketing Strategy of Indian Companies. *SAGE Open* **2016**, *6*, 1–19. [CrossRef]
80. Kjaer, L.L.; Pagoropoulos, A.; Schmidt, J.H.; McAloone, T.C. Challenges when evaluating Product/Service-Systems through Life Cycle Assessment. *J. Clean. Prod.* **2016**, *120*, 95–104. [CrossRef]
81. Kreijns, M.; Gerardts, R.; Rutten, M. Demonstration sites to speed up innovations in delta technology. *J. Clean. Prod.* **2018**, *171*, S144–S146. [CrossRef]

82. Weber, B.; Heidenreich, S. When and with whom to cooperate? Investigating effects of cooperation stage and type on innovation capabilities and success. *Long Range Plan.* **2018**, *51*, 334–350. [CrossRef]
83. BMAS. Supply Chain Act. 2023. Available online: https://www.bmas.de/EN/Europe-and-the-World/International/Supply-Chain-Act/supply-chain-act.html (accessed on 1 May 2026).
84. Blind, K.; Kenney, M.; Leiponen, A.; Simcoe, T. Standards and innovation: A review and introduction to the special issue. *Res. Policy* **2023**, *52*, 104830. [CrossRef]
85. Ambec, S.; Cohen, M.A.; Elgie, S.; Lanoie, P. The Porter Hypothesis at 20: Can Environmental Regulation Enhance Innovation and Competitiveness? *Rev. Environ. Econ. Policy* **2013**, *7*, 2–22. [CrossRef]
86. Brussels European Commission. *Flash Eurobarometer 498 (SMEs, Resource Efficiency and Green Markets, Wave 5)*; Gesis: Cologne, Germany, 2022.
87. European Commission. Report: SMEs, Green Markets and Resource Efficiency; Flash Eurobarometer No. 498. 2022. Available online: https://europa.eu/eurobarometer/surveys/detail/2287 (accessed on 1 May 2026).
88. Lundvall, B.-Å. National Innovation Systems—Analytical Concept and Development Tool. *Ind. Innov.* **2007**, *14*, 95–119. [CrossRef]
89. Mele, C.; Russo-Spena, T. Eco-innovation practices. *J. Organ. Change Manag.* **2015**, *28*, 4–25. [CrossRef]
90. Gomes, S.; Pinho, M.; Lopes, J.M. From environmental sustainability practices to green innovations: Evidence from small and medium-sized manufacturing companies. *Corp. Soc. Responsib. Environ. Manag.* **2023**, *31*, 1677–1687. [CrossRef]
91. European Commission. About the EU Ecolabel. 2023. Available online: https://environment.ec.europa.eu/topics/circular-economy/eu-ecolabel/about-eu-ecolabel_en (accessed on 1 May 2026).
92. Greene, W.H. *Econometric Analysis*, 7th ed.; Prentice Hall: Upper Saddle River, NJ, USA, 2012.
93. StataCorp. *Stata 18 Base Reference Manual*; Stata Press: College Station, TX, USA, 2023.
94. Nattino, G.; Pennell, M.L.; Lemeshow, S. Assessing the goodness of fit of logistic regression models in large samples: A modification of the Hosmer-Lemeshow test. *Biometrics* **2020**, *76*, 549–560. [CrossRef]
95. Too, M.A.; Alter, U.; Flora, D.B. Modelling Count Data in Psychological Research: An Applied Tutorial. *Int. J. Psychol.* **2025**, *60*, e70018. [CrossRef]
96. Ai, C.; Norton, E.C. Interaction terms in logit and probit models. *Econ. Lett.* **2003**, *80*, 123–129. [CrossRef]
97. Leydesdorff, L.; Etzkowitz, H. The Triple Helix as a model for innovation studies. *Sci. Public Policy* **1998**, *25*, 195–203. [CrossRef]
98. Teece, D.J.; Pisano, G.; Shuen, A. Dynamic capabilities and strategic management. *Strateg. Manag. J.* **1997**, *18*, 509–533. [CrossRef]
99. Weng, H.H.; Chen, J.S.; Chen, P.C. Effects of green innovation on environmental and corporate performance: A stakeholder perspective. *Sustainability* **2015**, *7*, 4997–5026. [CrossRef]
100. European Commission. Product Groups and Criteria Discover the Full Range of EU Ecolabel Products and Criteria. 2024. Available online: https://environment.ec.europa.eu/topics/circular-economy/eu-ecolabel/product-groups-and-criteria_en (accessed on 1 May 2026).
101. McDonald, R.I.; Chai, H.Y.; Newell, B.R. Personal experience and the 'psychological distance' of climate change: An integrative review. *J. Environ. Psychol.* **2015**, *44*, 109–118. [CrossRef]
102. Bichinho, S.; Franco, M.; Rodrigues, M. Interorganisational cooperation as a way of accessing green technologies for the integration of sustainable practices in SMEs. *Green Technol. Sustain.* **2026**, *4*, 100295. [CrossRef]
103. Hockerts, K.; Wüstenhagen, R. Greening Goliaths versus emerging Davids—Theorizing about the role of incumbents and new entrants in sustainable entrepreneurship. *J. Bus. Ventur.* **2010**, *25*, 481–492. [CrossRef]
104. Burbano, V.C.; Delmas, M.A.; Cobo, M.J. The Past and Future of Corporate Sustainability Research. *Organ. Environ.* **2023**, *37*, 133–158. [CrossRef]
105. Lu, Q.; Deng, J.; Chen, S.; Hussain, Y. Managerial myopia and its barrier to green innovation in high-pollution enterprises: A machine learning approach. *J. Environ. Manag.* **2025**, *376*, 124477. [CrossRef]
106. Diepenmaat, H.; Kemp, R.; Velter, M. Why Sustainable Development Requires Societal Innovation and Cannot Be Achieved without This. *Sustainability* **2020**, *12*, 1270. [CrossRef]
107. Kemp, R.; Diepenmaat, H.; Nieboer, L.; Wynarski, J. *SYSCHEMIQ Policy Briefs and Guidelines on the Circular Systemic Solutions Adopted*; Syschemiq Consortium: Maastricht, The Netherlands, 2025.

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