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Eco-innovation and SMEs' sustainable performance: a meta-analysis

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Abstract

Purpose – The study aims to build upon the Resource-based view of the firm (RBV) and Dynamic Capability Theory (DCT) to perform a meta-analysis on the eco-innovation/SMEs' sustainable performance relationship.
Design/methodology/approach – Employing a psychometric meta-analytic approach with a random-effects model, the study examines a sample of 134,841 SMEs covering 99 studies and 233 study effects. Subgroup and meta-regression analysis were used to test the study`s hypotheses in Comprehensive Meta-Analysis (CMA) statistical software.
Findings – Results unveil that the average impact of eco-innovation on SMEs` sustainable performance is positively significant but moderate. Moreover, it was found that eco-process, eco-product, eco-organizational, and eco-marketing innovations positively influence SMEs' sustainable performance, but the impact of eco-organizational innovation is the strongest. Findings further reveal that eco-innovation positively influences economic, social, and environmental performance, but its effect on social performance is the largest. Moreover, our findings reveal that contextual factors, including industry type, culture, industry intensity, global sustainable competitive index, and human development index, moderate the eco-innovation/SMEs' sustainable performance relationship. Lastly, methodological factors, namely sampling technique, study type, and publication status, account for study-study variance.
Practical implications – Our findings imply that investing in eco-innovation is worthwhile for SMEs. Therefore, CEOs/managers of SMEs must adopt eco-innovation initiatives by establishing a sustainability vision, developing employee environmental development and training, building a stakeholder management system, and promoting employee engagement in sustainability activities.
Originality/value – The study develops a holistic conceptual framework to consolidate the distinct types of eco-innovation and their association with the sustainable performance of SMEs for the first time in this research stream, thereby resolving the anecdotal results and synthesizing the fragmented literature across culture, discipline, and contexts.

Keywords Eco-innovation, Sustainable performance, SMEs, Meta-analysis, Eco-organizational innovation
Paper type Literature review

1. Introduction

With the ever-growing pressure from the marketplace and government concerning sustainability, building an effective eco-innovation agenda, and making it an integral part of a company`s strategic orientation has become a matter of necessity, not an option (Bag *et al.*, 2022). In response to this and to mitigate and ameliorate the exploitation of scarce resources, several SMEs have implemented innovation programs relating to environmental management and sustainability, such as sustainability business plans and operations, sustainability communication models with suppliers and customers, investment in

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sustainable options, the 3R model of waste reduction (reduction, recycling, and reuse), and environmental awareness training programs for employees (Phonthanukitithaworn *et al.*, 2023).

Eco-innovation refers to the "production, assimilation or exploitation of a product, production process, service or management or business methods that are novel to the organization (developing or adopting it) and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources used (including energy use) compared to relevant alternatives" (Kemp and Pearson, 2008, p. 7). Eco-innovation converts the conventional rectilinear system of production and ingestion into a circular economy (Geng *et al.*, 2021), with organizations, economies, and institutions advocating circular economy models that advance universal and fundamental eco-innovation to facilitate the global flow of inputs for production (Singh and Chakraborty, 2021). Eco-innovativeness helps firms introduce the 3Rs – reduce, reuse, and recycle into the process of manufacturing and consumption (Fehrer and Wieland, 2021), create opportunities for human society to relate to dynamic spheres of nature (Confente *et al.*, 2020), and prevent resource depletion while creating opportunities for sustainable development and growth (Jia *et al.*, 2020). Apart from their diaphanous number and economic relevance, SMEs commit significant resources to environmental sustainability due to their potential to impact innovation outcomes positively. SMEs, which account for more than 70% of clean tech enterprises (OECD, 2018), can play a vital role in ecological and green transformation because they possess the potential to stimulate considerable environmental improvements (OECD, 2018) by acting as green innovators or green performers (Afum *et al.*, 2021).

Research on eco-innovation has increasingly grown in the last few decades, albeit some pertinent issues remain open to research. First, while innovation and strategic orientations are shown as diverse in the SME context (Bag *et al.*, 2022), a preponderous of previous studies concentrate on large firms (Bos-Brouwers, 2010). But we stress that context counts, with SMEs varying in their orientations towards strategy adoption and implementation, especially in their capacity to devote resources to environmental sustainability than large enterprises. Notwithstanding, empirical evidence of eco-innovations of SMEs is broadly scattered across diverse cultures, disciplines, research domains, and journals. To this end, we lack a clear picture and an organizing framework for the eco-innovation/SMEs' sustainable performance relationship.

Second, there are numerous types of eco-innovation, encompassing process innovations, product innovations, marketing innovations, and organizational innovations (García-Granero *et al.*, 2020; Singh and Chakraborty, 2021). Although each archetype of eco-innovation has its contribution to environmental management (Damanpour *et al.*, 2009), scholars have primarily emphasized the performance and development of individual eco-innovation initiatives (Liu *et al.*, 2020). However, it has been noted that it is ineffective to implement innovation agendas separately without a systemic and holistic view (Cheng *et al.*, 2014). Likewise, from the sociotechnical systems theory, a firm must take a systemic perspective to develop and support its eco-innovation programs through appropriate managerial and social systems to optimize firm performance (Cheng *et al.*, 2014). Furthermore, researchers have examined organizational performance regarding operational efficiency, financial performance, reputation, innovation performance, etc. (Chege and Wang, 2020), but a few have discussed sustainable performance (e.g. Afum *et al.*, 2021). Sustainable performance measures the environmental, social, and economic consequences of a firm`s strategic orientation, like eco-innovation (Afum *et al.*, 2020). Moreover, research on eco-innovation has yielded inconsistent results as to the impact of implementing environmental programs, with some demonstrating strong positive associations (Singh and Chakraborty, 2021), some negative relationships (e.g. Jové-Llopis and Segarra-Blasco, 2018), and others showing non-significant relationship (e.g. Chege and

Wang, 2020; Geng *et al.*, 2021). One reason is that many studies are conducted in different cultures and sectors.

Another important gap in the literature that needs consideration is that the existing reviews on eco-innovation primarily arise from conceptual studies and qualitative reviews. For instance, Walker *et al.* (2008) carried out a review of the barriers and drivers of eco-innovation in SMEs. In another systematic review, Klewitz and Hansen (2014) performed a qualitative analysis of sustainable-oriented innovations in SMEs. Furthermore, Parker *et al.* (2009) reviewed the policy interventions of SMEs' eco-innovation. Lastly, the meta-analysis of Zubeltzu-Jaka *et al.* (2018) investigated the determinants of eco-innovation without differentiating without recourse to firm performance and without distinguishing between large and small firms. Therefore, before this study, there was no review that investigated the relationship between eco-innovation and the sustainable performance of SMEs via a meta-analysis. To this end, the prevailing reviews require further generalization and validation from large-scale quantitative studies like a meta-analysis. A meta-analytic review is an objective and quantitative method for synthesizing empirical research by providing statistically precise and reliable conclusions regarding the strength and direction of the relationships between variables (Paul and Barari, 2022). It also enables researchers to resolve mixed findings from prior studies by identifying the impact of moderator variables (Combs *et al.*, 2019).

Different from the prevailing reviews, this study aims to provide a systemic, holistic view of eco-innovation initiatives by examining the inter-relationships among variant kinds of eco-innovation and their effect on the sustainable performance of SMEs using a meta-analytic review approach. More specifically, the objective of the study is two-pronged: (1) to determine the extent to which eco-innovation affects the sustainable performance of SMEs while accounting for the relative and joint effects of the archetypes of eco-innovation; (2) to identify the contextual and methodological factors that moderate the eco-innovation/SMEs' sustainable performance relationship.

In doing so, this study provides theoretical and managerial contributions to the innovation and sustainability literature in several ways. First, it contributes to eco-innovation research by identifying four eco-innovation archetypes and developing a comprehensive conceptual framework to determine each type's effect on SMEs' sustainable performance. Because of the lack of a consolidative map demonstrating distinct eco-innovation types and performance outcomes, scarce knowledge exists regarding the interrelationships among the various types of eco-innovation and their joint and relative effects on sustainable performance. Hence, this research proposes comprehensively assessing the eco-innovation/sustainable performance relationship and further piloting scholars and practitioners to develop eco-innovation.

Second, this research integrates previous conflicting results on the eco-innovation/sustainable performance relationship by taking a quantitative stock of empirical evidence. Therefore, the study helps clarify the mixed results by determining the magnitude and direction of the focal relationship, which may vary according to practice category and performance measures. By aptly accounting for diverse types of eco-innovation and diverse aspects of SMEs' sustainable performance, this study advances the accuracy of estimates of the eco-innovation/sustainable performance relationship. Third, by considering omitted bias, heterogeneity of eco-innovation and performance outcomes, and a wide time frame, the study extends the prevailing conceptualizations and generalizations of SMEs and eco-innovation frameworks. In addition, this study is relevant to general management scholars and policymakers, as SMEs are the most prevalent form of business in any economy and are considered the engine of economic growth and catalyst for innovation.

Likewise, this research explores the boundary-spanning factors that may significantly moderate the eco-innovation/SMEs' sustainable performance relationship. In so doing, we offer explanations for the prior mixed findings and further facilitate and inform future

research, especially for exploiting organizational theories in this stream of research. Thus, the results can support practitioners in making informed decisions on leveraging eco-innovation by showing which eco-innovation type is more effective and which sectoral, industry intensity, country, and cultural characteristics have more potent effects or elasticities. Related to this, the analysis addresses how study characteristics such as sampling technique and study design are related to the differential efficacy of eco-innovation for different performance outcomes. This furnishes researchers with valuable insights concerning the consequences of their choice of methodological techniques. Finally, the study`s framework and findings provide a research agenda for further inquiry in this stream of research.

The succeeding section presents the study's theoretical background and develops research hypotheses, followed by a delineation of the methodological design, including data search and the meta-analysis process. The statistical findings of the analysis are presented next, and the results are discussed. The theoretical and managerial implications of the findings are discussed, and limitations and suggestions for further research are presented.

2. Literature review

2.1 Eco-innovation typology

While the literature defines eco-innovation differently, the consensus congregates on innovations mainly focused on sustainability and environmental management (Greco *et al.*, 2022). For instance, Kemp and Pearson (2008, p. 7) define it as the "production, assimilation or exploitation of a product, production process, service or management or business methods that are novel to the organization (developing or adopting it) and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources used (including energy use) compared to relevant alternatives" (Kemp and Pearson, 2008, p. 7). Hence, eco-innovation encapsulates two key facets, namely, (1) the environmental impact of innovation, positive or negative, and (2) the intention of the initiator of innovation (product/service), considering its environmental impact (Barbieri and Santos, 2020). This way, it has been stressed that innovations that do not consider environmental concerns are not categorized as eco-innovation (García-Sánchez *et al.*, 2020). The literature identifies different forms of eco-innovation. As a case in point, Arundel and Kemp (2009) proposed that eco-innovations comprise organizational, technical, and marketing innovations. Del Río *et al.* (2010) categorized eco-innovation types into radical/incremental, mature/immature, and process/product. Klewitz and Hansen (2014) and Triguero *et al.* (2013) identified three eco-innovation types: eco-organizational, eco-process, and eco-product innovations. The Oslo Manual by the OECD (2005) proposes four types of eco-innovation: process innovation, product innovation, organizational innovation, and marketing innovation. When investigating internal innovation, the literature focuses on eco-product, eco-process, eco-organizational, and eco-marketing innovation activities (Bag *et al.*, 2022; Triguero *et al.*, 2013). Thus, these four eco-innovation types are synthesized and their association with the sustainable performance of SMEs. Although previous studies tend to examine these types of eco-innovation separately, their joint and relative effects are scarcely examined systemically in this stream of research (Cheng *et al.*, 2014), thereby forming the thrust of this meta-analysis. The following section elucidates activities associated with these four types of eco-innovation.

2.1.1 Eco-innovation typologies. Eco-product innovation involves the development of new or significantly enhanced products (features) like improvements in materials and technical components (Chen and Liu, 2020). For example, eco-design can enhance products via eco-benign components (e.g. recycled, organic materials) and minimal energy consumption. Areas of eco-innovations in the product include eco-design for the environment, life cycle analysis, and eco-labeling (Clancy *et al.*, 2015; Afum *et al.*, 2020). Klewitz and Hansen (2014) summarized the eco-product innovation of SMEs to include eco-design/design for the

environment, life-cycle analysis, eco-label, materials (reduce, replace, sustainable, recycled resources, biodegradables), organic products, and packaging. For instance, research shows that SMEs can reduce their pollution effects, augment their eco-efficiency, and optimize their resource features by making a product simpler to reuse, decompose, or recycle (Le and Ikram, 2022).

Eco-process innovation refers to introducing novel elements into a firm`s production system and procedures to produce eco-products (Alraja *et al.*, 2022). Generally, eco-process innovation involves adding new processes or improving existing manufacturing processes to minimize negative environmental impact and augment metabolic consistency (i.e. eco-effectiveness) or eco-efficiency (Huber, 2008). Research notes that eco-process innovation can be additive solutions, cleaner production technologies, or be integrated into the manufacturing processes via reclamation of outputs, optimization of production, and substitution of inputs.

Eco-organizational innovation involves upgrading the firm`s management processes through novel and eco-approach in business practices (Birkinshaw *et al.*, 2008). It entails reorganizing the structures and routines within an organization and introducing more formalized management systems like environmental management systems (OECD, 2005; Rennings *et al.*, 2006). Eco-organizational innovation includes product design programs, eco-training programs, eco-learning techniques, and the establishment of environmental management teams, departments, or cross-functional committees and units to deal with ecological concerns (Singh and Chakraborty, 2021). Klewitz and Hansen (2014) identified areas of eco-organizational innovation in SMEs to include sustainability vision, employee development and training, stakeholder management, code of conduct, and employee engagement in sustainability activities.

Eco-marketing innovation "Consists of actions directed to all consumers and incorporates a broad range of marketing activities (e.g. planning, process, production, promotion, and people) designed to demonstrate the firm's goal of minimizing the environmental impact of its products and services" (Groening *et al.*, 2018, p. 1851). Eco-marketing innovation includes all kinds of promotion that implies environmental and climate benefits. Eco-marketing innovation involves marketing green products, prices, advertising, and distributions (Chege and Wang, 2020). Table 1 provides an overview of the eco-innovation types and business metrics used in capturing the literature.

2.2 Sustainable performance

The concept of sustainable performance emerged from sustainable development and is defined as the combination of firms' economic, social, and environmental performances (Chardine-Baumann and Botta-Genoulaz, 2014). Economic performance relates to a firm`s financial and economic prospects optimization. Social performance refers to the consequences of firm efforts in managing reputation, social image, and customer relationships (Liu *et al.*, 2023). Social performance is also measured using indicators like improvement in employee safety and health, improvement in the quality of life of the community, improvement in work conditions, and vocational training for community members and training of employees (Afum *et al.*, 2021; Abdul-Rashid *et al.*, 2017). Lastly, environmental performance addresses an organization`s ability to reduce the negative impacts of its business activities on the environment. This includes reducing solid waste and pollution, unsafe materials, and environmental accidents (Singh and Chakraborty, 2021; Afum *et al.*, 2020). Following the literature in categorizing sustainable performance, we grouped the performance measures based on the core measurements of each performance indicator in the previous empirical studies and then proposed an integrative, holistic approach to sustainable performance, as shown below in Table 2.

Eco-innovation type	Business metrics	Sample articles
Eco-product innovation	Eco-design/design for environment), life-cycle analysis, eco-label, Materials (reduce, replace, Sustainable, recycled resources, biodegradables), organic products packaging	Singh *et al.* (2020) Afum *et al.* (2020) Chen and Liu (2020) Klewitz and Hansen (2014)
Eco-process innovation	Cleaner production, Waste handling (e.g. recycling, water, sewage, and air pollution Eco-efficiency, Logistics (e.g. efficient transportation)	Singh *et al.* (2020) Ullah *et al.* (2021) Singh *et al.* (2020) Klewitz and Hansen (2014)
Eco-organizational innovation	EMS, ISO 14001/EMAS Environmental policy,Environmental Management Accounting, Innovation Process (e.g. interaction with external actors, biomimicry	Khoja *et al.* (2022) Bag *et al.* (2022) Klewitz and Hansen (2014)
Eco-marketing innovation green product	Supply chain management, green advertising, green distribution, transportation emissions, carbon footprint, green purchasing	Chege and Wang (2020) Geng *et al.* (2021) Zhu *et al.* (2017)

Source(s): Authors' own creation

Table 1. Eco-innovation types

Performance type	Measurement	Sample articles
Economic performance	profitability, growth, capital market returns,sales, growth, return on asset, return on equity return on investment	Afum *et al.* (2020) Afum *et al.* (2021) Liu *et al.* (2023)
Social performance	customer satisfaction, customer acquisition and retention, organizational reputation and image, and brand awareness,employee safety and health, improvement of work conditions	Bag *et al.* (2022) Liu *et al.* (2023) Afum *et al.* (2021)
Environmental performance	Energy consumption/volume Consumption of hazardous materials Environmental audits Emissions, waste treatment	Jia *et al.* (2020) Maroufkhani *et al.* (2020) Afum *et al.* (2021) Khoja *et al.* (2022)

Source(s): Authors' elaboration

Table 2. Sustainable performance metrics

2.3 SMEs

SMEs are a heterogeneous type of business in terms of sector and size diversity (Bag *et al.*, 2022). Generally speaking, it is challenging to conceptualize SMEs. This, in part, is due to the different criteria adopted by various countries in defining SMEs. While some countries use the number of employees (employment), others use sales and turnover (annual returns). According to the OECD classification, SMEs employ fewer than 250 persons and have an annual turnover not exceeding EUR 50 million and an annual balance sheet total not exceeding EUR 43 million (European Commission, September 2019, EU, 2020). Examining the eco-innovation practices of SMEs is relevant for the following reasons. First, SMEs account for a large share of companies in any economy internationally. The OECD (2011) shows that

SMEs account for between 96% and 99% of the total number of companies. Second, research shows that SMEs contribute to a large portion of total pollution (Whitehead, 2013), and in the European Union (EU), SMEs account for approximately 64% of overall pollution (European Commission Eco-Innovation report, 2020). Third, SMEs' peculiarities inspire them to innovate differently regarding environmental management and sustainability than their larger counterparts (Bos-Brouwers, 2010). Research points out that SMEs have disadvantages or constraints (resource constraints, lack of formalized planning, difficulty in attracting finance), which can impede their ability to proactively engage in the innovation process. In this regard, it has been shown that SMEs demonstrate a "reactive" attitude toward environmental and social concerns. At the same time, scholars postulate that non-structured and informality features of SMEs must not be necessarily deemed as deficient (Marlow *et al.*, 2010) since flexibility can enhance the capabilities of SMEs to manage ambiguity. SMEs have advantages since they are characterized by owner-managers, entrepreneurial style with lean organizational structures, and are strongly value-driven (Kong *et al.*, 2009). Therefore, SMEs can innovate radically and compete successfully in niche markets with eco-innovation (Alam *et al.*, 2022). SMEs, which account for more than 70% of clean tech enterprises (OECD and Paris, 2017), can play a vital role in ecological and green transformation because they possess the potential to stimulate considerable environmental improvements (OECD, 2018) by acting as green innovators or green performers (Afum *et al.*, 2021).

2.4 Theoretical background and hypotheses development

This study draws on the resource-based view of the firm (RBV) and Dynamic capabilities theory (DCT), being theoretical perspectives rooted in strategic management. RBV suggests that companies can realize a competitive advantage by securing valuable, rare, inimitable, and non-substitutable resources. Resources can comprise knowledge, assets, skills, relations, and capabilities (Barney and Mackey, 2016; Barney, 1991). As the relevance of strategic "Organization" of resources became apparent, the RBV of the firm evolved into the VRIO (Value, Rarity, Imitability, and Organization) framework. The RBV of the firm establishes the nexus between strategy and organizations' internal resources through the VRIO model (Ardito *et al.*, 2021). However, researchers have decried the RBV for its inability to explain how resources are exploited to accomplish competitive advantage (DeSarbo *et al.*, 2005) and the performance differences of firms despite possessing enough resources (Bag *et al.*, 2022). To compensate for the weaknesses of the RBV, Teece *et al.* (1997), Teece (2007) developed the DCT that underscores reconfiguring, adapting, appropriating, and integrating external and internal organizational competence to match the demands of the versatile business environments. Thus, competence is viewed as the cornerstone of competitiveness, as it helps firms innovate new processes, products, and organizations, offer unique value to customers, and develop a sustainable competitive advantage (Van Kleef and Roome, 2007). Thus, the DCT complements the RBV as a theoretical lens that explains the basis of competitiveness. Accordingly, we argue that eco-product innovation, eco-process innovation, eco-organizational innovation, and eco-marketing innovation can be seen as distinctive green competence and capabilities fostered with resources such as knowledge, organizational activities, structure, eco-technologies, administrative support, green infrastructure, etc. Developing these resources through ecological capabilities advances unique ecological competencies and abilities in the form of the four types of eco-innovation, which, in turn, facilitate the sustainable performance of SMEs.

2.5 Hypotheses development

In this aspect of the study, we develop eleven (11) hypotheses to investigate the holistic nexus between eco-innovations and SMEs' sustainable performance and to test the boundary-

spanning factors that can moderate the magnitude of eco-innovations/sustainable performance nexus. The conceptual model that demonstrates all the proposed hypotheses in the study is illustrated in Figure 1.

2.5.1 Eco-innovation and sustainable performance. Research provides empirical evidence to underpin the potential nexus between eco-innovation and sustainable performance, arguing that strategically implementing eco-innovations can improve organizations' competitiveness in innovation, operations, and marketing (Bag *et al.*, 2022). However, because of the absence of holistic, systemic eco-innovation guidelines in SMEs, there exist inconsistent findings on the eco-innovation/sustainable performance nexus, varying from positive, significant nexus (Singh and Chakraborty, 2021) to no significant relationships (e.g. Chege and Wang, 2020) and even negative significant relationships (Jové-Llopis and Segarra-Blasco, 2018). For example, across 178 manufacturing companies in Ghana, Afum *et al.* (2020) found that eco-innovation significantly influences SMEs' economic, social, and environmental performance. Likewise, evidence shows that eco-innovation positively affects environmental performance (Le and Ikram, 2022; Madaleno *et al.*, 2020) and social performance (Baeshen *et al.*, 2021). In contrast, some studies show that eco-innovation does not significantly affect economic performance (Chege and Wang, 2020; Namagembe *et al.*, 2019), environmental performance (Geng *et al.*, 2021), and social performance (Sezen and Cankaya, 2013). Despite the mixed results, we draw on the RBV of the firm and DCT to stress that, by integrating eco-innovation programs, SMEs can secure unique resources and capabilities, which can tremendously contribute to their innovation process and enhance their sustainable performance. This leads us to the first hypothesis of the study:

H1. Eco-innovation is positively related to the sustainable performance of SMEs: (a) overall, (b) economic performance, (c) environmental performance, and (d) social performance.

2.5.2 Eco-product innovation and sustainable performance. Cheng *et al.* (2014) and Xie *et al.* (2019) found that eco-product innovation positively relates to economic performance. Similarly, some researchers have noted that eco-innovations in the product enhance environmental performance (Singh and Chakraborty, 2021) and social performance (Ar, 2012). In contrast, some studies have also argued that eco-product innovation is not significantly related to economic performance (Chege and Wang, 2020; Mishra *et al.*, 2019; Sezen and Cankaya, 2013), environmental performance (Mishra *et al.*, 2019), and social performance (Sezen and Cankaya, 2013). Yet, the RBV and DCT argue that eco-product resources and capabilities can enhance firms' performance. Thus, we hypothesize that:

H2. Eco-product innovation is positively related to the sustainable performance of SMEs: (a) overall, (b) economic performance, (c) environmental performance, and (d) social performance.

2.5.3 Eco-process innovation and sustainable performance. Some sustainability and innovation management studies have established a positive eco-process innovation/SMEs' economic performance (Sezen and Cankaya, 2013; Singh and Chakraborty, 2021), environmental performance (Afum *et al.*, 2020; Maziriri, 2020), and social performance relationships (Singh and Chakraborty, 2021; Maziriri, 2020; Saengchai *et al.*, 2019). In this regard, SMEs can adjust their operation system and process, reduce unit costs of production, generate novel or significantly enhanced eco-products, and decrease environmental negative impacts (Ullah *et al.*, 2021), thereby improving sustainable performance. However, some studies observe that SMEs do not benefit from eco-process innovation programs in terms of economic performance (Chege and Wang, 2020), environmental performance (Geng *et al.*, 2021), and social performance (Chege and Wang, 2020). However, drawing on the RBV and

DCT, we argue that eco-innovation in the process of SMEs' business activities can enhance their sustainable performance. Accordingly, we propose that:

H3. Eco-process innovation is positively related to the sustainable performance of SMEs: (a) overall, (b) economic performance, (c) environmental performance, and (d) social performance.

2.5.4 Eco-organizational innovation and sustainable performance. The extant literature offers evidence to support the positive eco-organizational innovation/sustainable performance relationship, wherein SMEs can simultaneously enhance performance by promoting required changes, ameliorating workplace satisfaction, minimizing transaction and administrative costs, or plummeting the cost of supplies (Baeshen *et al.*, 2021). As a case in point, empirical findings show that eco-organizational innovation positively affects economic performance (Afum *et al.*, 2020; Chen and Chang, 2013), environmental performance (Geng *et al.*, 2021; Setyawati *et al.*, 2020), and social performance (Hong *et al.*, 2019; Afum *et al.*, 2020). Nevertheless, some studies countersense these findings, noting that SMEs' ability to undertake eco-organizational innovation does not affect their economic performance (Ali *et al.*, 2021) and environmental performance (Kim *et al.*, 2021; Shin and Cho, 2022). Notwithstanding the conflicting results, based on the RBV and DCT, we stress that SMEs' endeavors toward restructuring, renewing, and redesigning organizational procedures, systems, systems, or routines to generate eco-innovation can enhance their sustainable performance. Therefore, we posit that:

H4. Eco-organizational innovation is positively related to the sustainable performance of SMEs: (a) overall, (b) economic performance, (c) environmental performance, and (d) social performance.

2.5.5 Eco-marketing innovation and sustainable performance. Research (e.g. Chege and Wang, 2020; Geng *et al.*, 2021; Zhu *et al.*, 2017) indicates that eco-marketing innovations are related significantly to economic performance. Likewise, green marketing programs can improve SMEs` environmental performance (Rajeshwari and Harani, 2021; Mishra *et al.*, 2019) and social performance (Asad *et al.*, 2021). However, several studies point to a non-significant relationship between eco-marketing innovation and economic performance (Alraja *et al.*, 2022; Mishra *et al.*, 2019; Namagembe *et al.*, 2019), social performance (Chege and Wang, 2020; Mishra *et al.*, 2019), and environmental performance (Mishra *et al.*, 2019). Despite the mixed results, we build upon the RBV and DCT to stress that adopting and integrating eco-marketing initiatives and actions into business operations can positively affect sustainable performance as they handle stakeholders' (e.g. suppliers, customers) concerns about climate and sustainability. Followingly, we propose that:

H5. Eco-marketing innovation is positively related to the sustainable performance of SMEs: (a) overall, (b) economic performance, (c) environmental performance, and (d) social performance.

2.6 Moderators

The nexus between eco-innovations and sustainable performance has been investigated in several disciplines and contexts. To this end, we draw on the extant literature to propose the below contextual and methodological moderators that may account for between-study variance in the eco-innovation/sustainable performance relationships: Contextual – sector, industry intensity, human development index (HDI), culture (individualism), and global sustainability competitive index (GSCI); methodological – sampling technique, study type, and publication status.

2.6.1 Contextual factors. Our first contextual variable is culture. According to the cultural difference theory, environmental-related attitudes may vary between countries and national cultures (Gumperz, 1982; Bitencourt *et al.*, 2020). Based on this theoretical perspective, this study draws on Hofstede`s cultural model, specifically individualism versus collectivism, to examine how this may influence the eco-innovation/sustainable performance links. On the one hand, scholars argue that in individualistic cultures where personal goals and interests prevail over collective goals and interests, there is a limited focus on the environment (Morren and Grinstein, 2016), while collective cultures have better environmental performance since they care about the well-being of the society and others (Gallego-Álvarez and Ortas, 2017). On the other hand, research shows that individualistic cultures are more likely to protect the environment due to their personal motives, like social status. In this study, we stress that the eco-innovation/sustainable performance nexus is higher in collectivist societies due to their general concern for the well-being of the environment. Thus, we propose that:

H6. The relationship between eco-innovation and sustainable performance is higher in collectivist than individualistic cultures.

The second contextual variable is the Global Sustainability Competitive Index (GSCI). GSCI measures the sustainable competitiveness of countries using 111 SolAbility measures, grouped into six key indicators (1) resource efficiency and intensity, (2) natural capital, (3) governance efficiency, (4) intellectual capital, (5) economic sustainability, and (6) social cohesion (SolAbility's, 2022). According to the competitiveness theory, nations can enhance their national competitiveness by introducing innovative eco-friendly technologies by exploiting their natural capital, governance efficiency, intellectual capital, and resources, which, in turn, affect firms' environmental behavior (Blagova and Korkova, 2018). Following previous studies (e.g. Bitencourt *et al.*, 2020), we used SolAbility's (2022) average score of 45 as the median to group the countries into low and high GSCI levels. We propose that the GSCI of a nation can affect the eco-innovation performance of its companies since a high GSCI presupposes a high inclination towards sustainable and environmental development. Thus, we posit that:

H7. The relationship between eco-innovation and sustainable performance is higher in countries with high GSCI than those with low GSCI.

Next, we tested the effect of country development on the eco-innovation/sustainable performance relationship using the human development index (HDI) of nations. The extant literature indicates that the impact of eco-innovation on sustainable performance may differ across countries (Horbach, 2016). HDI tackles the economic growth of nations based on different parameters such as level of education, GDP, per capita income, and resource endowment, among others. Developed countries in America, Europe, and Oceania, compared to those in emerging markets like Africa and South America, may possess superior innovation infrastructures, human capital, and financial resources for companies to exploit, develop, and execute several eco-innovation strategies (Sarasini *et al.*, 2014). From the structural economic theory front, structural differences between countries, how economies adjust, and their responsiveness to development policies may affect the rate at which green or sustainable innovations and best environmental practices may spread to all countries worldwide (Horbach, 2016). Following previous studies, we grouped nations into low and high HDI based on the countries of origin and the median value benchmarked by the United Nations. Therefore, with more eco-innovation experience, firms in countries with high HDI are likelier to achieve a much stronger relationship between eco-innovation and sustainable performance than those in with low HDI. Accordingly, we propose that:

H8. The relationship between eco-innovation and sustainable performance is higher in countries with high HDI than those with low HDI.

Furthermore, we test the moderation effect of industry type on the eco-innovation/sustainable performance relationship. The dynamic capabilities theory proposes that an organization's ability to integrate and reconfigure resources and competencies might vary by industry type and, ultimately, firm performance (McWilliams and Siegel, 2011). Oduro *et al.* (2021a) show that green innovation concentrates more on manufacturing than service and agriculture. Research also demonstrates that because of the product-orientated nature of manufacturing firms, the levels of innovation, eco-efficiency, and sustainable practices required to implement eco-innovations in manufacturing firms call for cost-saving strategies to minimize cost and increase sales and market share (Garay and Font, 2012) unlike service firms. Thus, manufacturing firms are expected to be empowered to adopt eco-innovative technologies to augment performance. Therefore, we propose that:

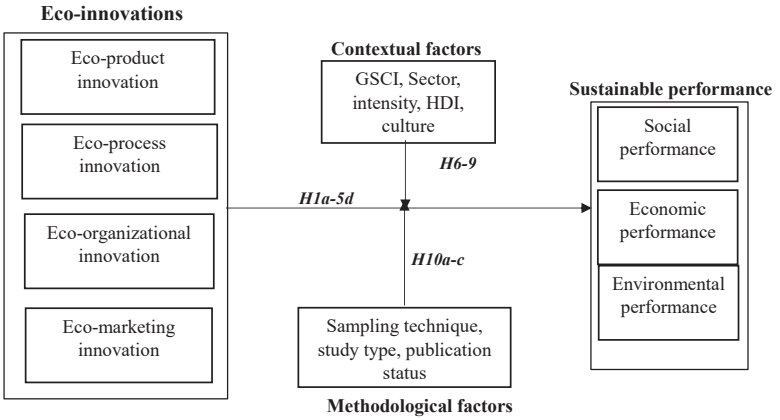
H9. The relationship between eco-innovation and sustainable performance is higher in manufacturing than in service firms.

Lastly, we explore the moderation effect of industry intensity on the eco-innovation/sustainable performance relationship. High tech (e.g. high-tech services like software, high-tech semiconductors, and pharmaceutical sectors) compared to low tech (e.g. hospitals, textiles, B2C firms). The high-tech firms may have more urge to invest in eco-innovations due to the technology-based innovations to enhance performance compared to their low-tech counterparts (Mubarak *et al.*, 2021). On the other hand, some researchers also indicate that low-tech firms usually benefit from constant stability from IT investment, slow product updates, and high homogeneity (Santoro *et al.*, 2020). In addition, low-tech firms are more likely to invest in eco-innovations because of their stronger need for operational efficiency and business model innovations. Therefore, we propose the following:

H10. The relationship between eco-innovation and sustainable performance is higher in low-tech than in high-tech SMEs.

2.6.2 Method moderators. Apart from contextual factors, researchers point out that the methodological choice of a researcher can influence the force of the focal relationship (Oduro *et al.*, 2021a, b). For this reason, we explored sampling technique (probabilistic vs. non-probabilistic), publication status (published vs. non-published), and study type (cross-section vs. longitudinal) as method factors. Studies show that probabilistic sampling minimizes random errors of variance and, thus, is verged to produce stronger effect sizes than the non-probability sampling technique. Similarly, it has been shown that longitudinal studies may make more precise estimates of treatment effects than cross-sectional studies due to their statistical power to eliminate between-individual variation, reducing bias (Oduro *et al.*, 2022). Lastly, scholars are divided concerning the preference for published studies with significant study effects (Rosenthal and DiMatteo, 2001). Hence, we grouped the studies into scientific publications in journals (published) and theses, conferences, or working papers (unpublished). Thus, we propose this last hypothesis:

H11. (a) Sampling technique, study type, and publication status positively account for between-study variance in the eco-innovation – sustainable performance relationships



Source(s): Authors' own creation

Figure 1.
Meta-analytic framework

3. Methodology

3.1 Articles search process

Following prior meta-analytic reviews in the innovation literature (Liu *et al.*, 2023; Klewitz and Hansen, 2014), we began the review with a bibliographic keyword to identify articles that investigated the association between eco-innovation and sustainable performance of SMEs from 2006–2022 in internationally recognized business and management databases, including Scopus, Web of Science, and EBSCO. Furthermore, a reference analysis was carried out in the previous systematic reviews and a manual search in some leading innovation journals like the *Journal of cleaner production, Journal of Innovation Management, Journal of Small Business Management, Small Business Economics, Technovation, Technological Forecasting and Social Change*, *Research Policy, JPIM, European Journal of Innovation Management*, *R&D Management, Business Strategy and the Environment,* where studies on eco-innovation and sustainable performance are most probable or frequently published to optimize the identification of relevant articles.

We performed the search process by entering the below keywords in the title, abstract, and keywords field in the databases using the Boolean operations such as "OR, AND, NOT: **eco-innovation** (e.g. "*eco-innovation," "green innovation," "product innovation," "process innovation," "marketing innovation," "eco-process innovation", eco-product innovation, "eco-sustainable innovation," "green marketing," "sustainable-oriented innovation," "eco-marketing innovation"," "ecological marketing," "lean manufacturing," "green supply chain," "eco-organizational innovation" "ecological innovation," "technological innovation," "environmental innovation*," "***Sustainable performance*** *(e.g. SMEs sustainable performance", "SMEs performance," "sustainable performance," "business model innovation," new product development," "business performance," economic performance," "operational performance," "environmental performance," ""sustainability performance", "reputation," "firm growth," "innovation performance," "social performance," ROA, ROE, market share, profit, economic performance, sales revenue, etc.);* ***SMEs*** *(e.g. SMEs, small business," "small enterprise," "small and medium enterprise," "small business management").*

3.2 Inclusion and exclusion criteria

We have included articles in the study using these criteria: (1) English language, full-text online scholarly articles that examined at least one dimension of eco-innovation (e.g. eco-

process, eco-product, eco-marketing, eco-organizational) in association with at least one sustainable performance dimension (economic, social, environmental) in SMEs; thus, the study had to be focused on the eco-innovation/SMEs sustainable performance; (2) the study must be quantitatively manipulated; that is, the study reports coefficient metric or enough statistical information to permit the computation of correlation coefficients; (3) studies without correlation coefficients provide r-variants (*F*-test, *T*-test, regression, *p*-value, etc.) which can be converted to r-coefficients. We obtained 1,245 papers in the first phase of the search. Of this, 234 duplicates and 457 non-statistically (qualitative) analyzed articles were removed, reducing the total to 691. Then, we filtered them using different elements such as scholarly articles, full text, and English language papers, thus reducing the total to 478. Next, we reviewed the articles based on the abstracts, and 109 papers were retained. After the inclusion and exclusion phases, 99 full-text, quantitative articles were identified, with 134,841 observations and 233 effects, from 2006 to 2022, which met our study`s specification and inclusion criteria. Our selection process is shown in Figure 2.

The final sample was coded based on the following coding scheme: conceptual features (i.e. eco-innovation, eco-process innovation, eco-product innovation, eco-marketing innovation, eco-organizational innovation, sustainable performance); specific sustainable performance (economic performance, social performance, environmental performance); and moderators – contextual characteristics (e.g. culture, industry, country development), and methodological features (publication status, study type, sampling technique). The coding scheme also included basic information on statistics: sample size, means and standard deviation, and correlation coefficients (including r-variants-beta, *p*-value, t-value, etc.). Each author coded the independent, dependent, and moderating variables separately according to the coding scheme. The inter-rater reliability was 96% of the coding decisions. Any disagreements were resolved through discussion and cross-examinations, thereby confirming the study's validity.

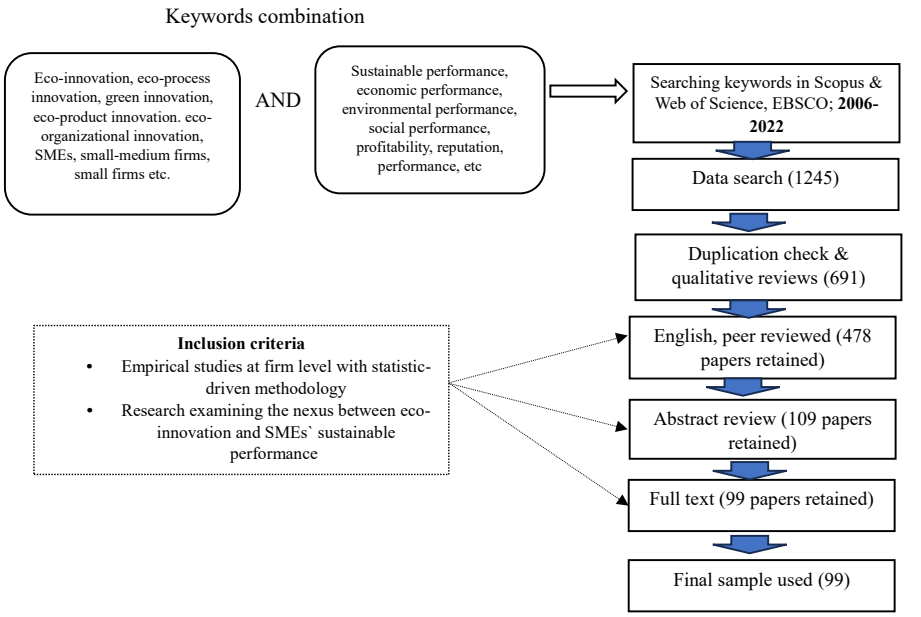


Figure 2.
Data search and identification

Source(s): Authors' own elaboration

3.3 Meta-analytic metric and integration of effect sizes

We employed the Pearson correlation coefficient metric as the meta-analytic metric based on the following reasons: (a) it is easy to interpret, (b) it permits *r-contrast* to be computed when no correlation coefficients are directly reported (Oduro *et al.*, 2022), and (c) it is the standard metric most commonly employed in business and management literature (Liu *et al.*, 2023; Rosenbusch *et al.*, 2019). The correlation coefficients were either picked directly from the study or computed through the r-variants (Roschk *et al.*, 2017). When a study provides only the *p*-values, the conversion procedure suggested by Rosenthal and DiMatteo (2001, p. 72) was used to convert them to correlation coefficients. In the case of regression coefficients, we converted them to r-correlations based on the formula proposed by Peterson and Brown (2005): $r = 0.98\,\beta + 0.05\lambda$ with $\lambda = 1$ when $\beta > 0$ and $\lambda = 0$ when $\beta < 0$. When a study reported more than one correlation coefficient for the same relationship (e.g. social performance indicators, e.g. reputation and customer satisfaction), we averaged the effect sizes to overcome the issue of sample overrepresentation (Kirca *et al.*, 2005; Roschk *et al.*, 2017).

Next, we adjusted the effect sizes for reliability to correct for attenuation emanating from random measurement error (Hunter and Schmidt, 2004). In this case, the effect sizes (rxy) were divided by the square root of two variable measurement reliability products $\sqrt{(rxx)} * \sqrt{(ryy)}$. Moreover, we used the mean sample size-weighted reliability in the studies that employed single-item measures or did not provide reliability indices (Hunter and Schmidt, 2004). Finally, we evaluated the sample-size weighted means of all the correlation coefficients across the studies for each association, denoted as *rz* (Hunter and Schmidt, 2004).

3.4 Meta-analysis model

We adopted the random-effects model as the meta-analysis model due to the diverse theoretical and methodological differences across the primary studies. Unlike the fixed effect, the random-effects model assumes that the between-study variance differs for all subgroups and studies that used diverse methodologies (Borenstein *et al.*, 2021). We also addressed the case that multiple effect sizes from a single study are more likely to be correlated, which generates invalid statistics and inaccurate inferences in hypothesis testing, by employing Huber-White (H–W) OLS in attuning the variance-covariance matrix to correct for autocorrelation within studies and for arbitrary heterogeneity. This process helps obtain robust standard errors (Wooldridge, 2006). Lastly, because environmental factors (contextual factors) may be highly correlated, potentially leading to multicollinearity issues, we followed previous meta-analyses (e.g. Mueller *et al.*, 2013) to include the contextual variables in separate models in the meta-regression analysis.

3.5 Publication bias

Publication bias means that positive results are more accessible to publish than negative ones (Hunter and Schmidt, 2004). For this reason, we tested publication bias by including unpublished papers (theses, conference proceedings, working papers) and assessing them based on the conventional method known as the *funnel plot*. As shown in Figure 3, the funnel plot shows no problem with publication bias issues (see Figure 4).

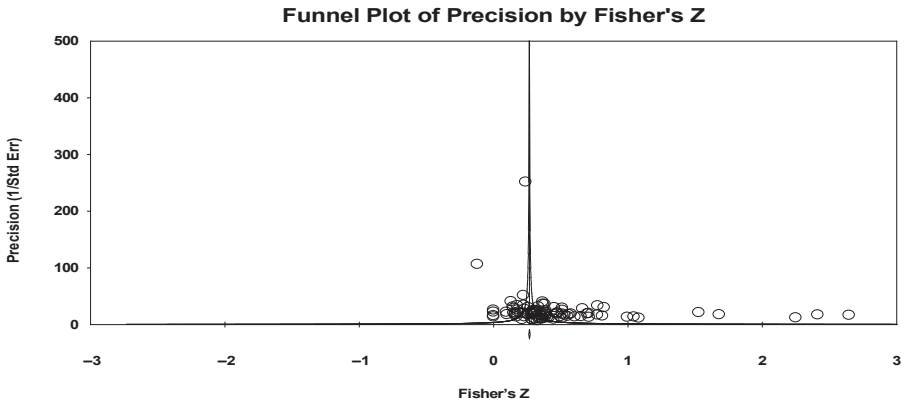


Figure 3.
Publication bias

Source(s): Authors' own elaboration

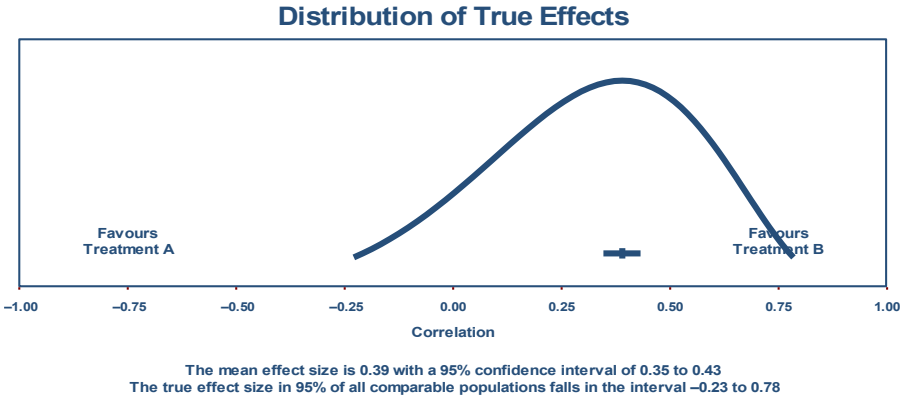
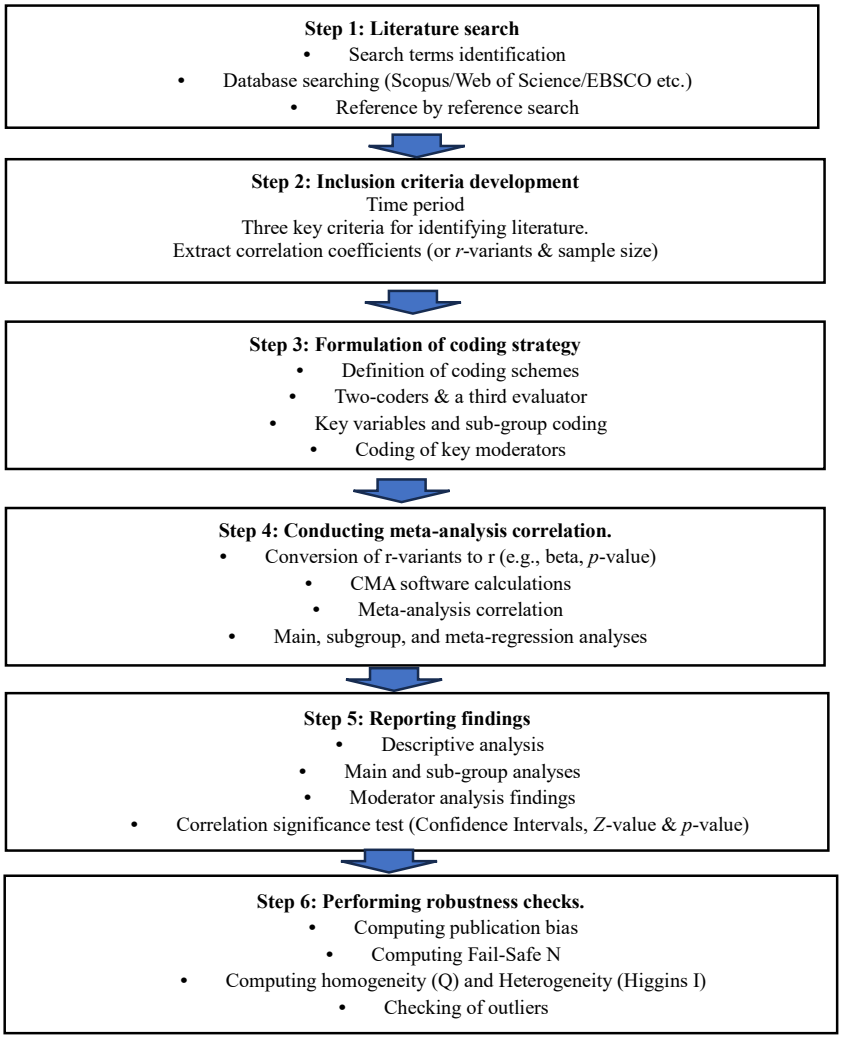


Figure 4.
Distribution of true effects

Source(s): Authors' own elaboration

3.6 Homogeneity test

We employed Q and Higgin (I-square) statistics to assess the heterogeneity of the generalizable effect sizes (study-to-study variance). Finally, the significance of the moderator analysis was evaluated through subgroup analysis using QB and meta-analytic regression analysis (MARA), which simultaneously examines the relationship's interdependencies. Our meta-analytic processes in shown in Figure 5.



Source(s): Own elaboration

Figure 5.
Meta-analytic process

4. Findings

4.1 Eco-innovations and SMEs' sustainable performance

Table 3 reveals the meta-analysis findings of the association between eco-innovations and sustainable performance of SMEs with 233 effects. In this study, effect sizes below or equal to 0.20 are small; from 0.21 to 0.50 are moderate; and greater than 0.50 as large (Cohen, 1988). Our findings show that the relationship between overall eco-innovation and overall SMEs' sustainable performance is significantly positive but moderate ($r = 0.390$; $p = 0.000$), as the confidence intervals do not include zero. The Fail-safe N is also robust, disclosing that 16,632 studies are required to render this result non-significant. This implies that strategically implementing eco-innovations can improve SMEs' economic, social, and environmental competitiveness (Bag *et al.*, 2022; Le and Ikram, 2022). Therefore, contrary to the notion that the eco-innovation/sustainable performance relationship is not significant (e.g. Chege and Wang, 2020) or even negative (Jové-

	N	K	rz	−CI	+CI	Z	*p*	Q	I-S	FSN
Overall eco-innovations effect										
H1a: Eco-innovation-performance	134,841	233	0.390	0.346	0.432	16.02	0.000	9163.3	99.51	16,639
H1b: Economic performance	95,906	87	0.371	0.311	0.432	10.87	0.000	5612.71	98.47	1894
H1c: Environmental performance	13,751	59	0.421	0.341	0.491	9.899	0.000	1,587.86	96.35	8,539
H1d: Social performance	4,695	23	0.580	0.382	0.738	4.904	0.000	1819.66	98.79	2,366
Disaggregate eco-innovation dimensions										
H2a: Eco-product innovation	12,694	56	0.349	0.283	0.411	9.776	0.000	934.44	94.11	6,792
H2b: Economic performance	4,722	22	0.292	0.172	0.401	4.792	0.000	366.63	94.27	2075
H2c: Environmental performance	2,747	13	0.370	0.221	0.512	4.496	0.000	233.67	94.87	1,281
H2d: Social performance	928	06	0.501	0.191	0.717	3.031	0.002	137.816	96.37	409
H3a: Eco-process innovation	15,776	68	0.405	0.334	0.473	10.123	0.000	1854.6	96.39	11,268
H3b: Economic performance	5905	25	0.381	0.233	0.513	4.689	0.000	992.21	97.58	6,063
H3c: Environmental performance	3,498	18	0.467	0.361	0.561	7.507	0.000	254.63	93.32	3,946
H3d: Social performance	1,437	07	0.540	0.187	0.78	2.813	0.005	377.59	98.41	870
H4a: Eco-organizational innovation	12,437	46	0.422	0.315	0.518	7.156	0.000	2,149.9	97.91	8,232
H4b: Economic performance	3,907	16	0.372	0.262	0.47	6.418	0.000	201.48	92.55	1851
H4c: Environmental performance	3,427	14	0.361	0.261	0.46	6.400	0.000	148.66	91.25	1,578
H4d: Social performance	747	04	0.631	0.451	0.75	5.890	0.000	31.610	90.51	410
H5a: Eco-marketing innovation	9645	29	0.314	0.251	0.375	9.220	0.000	326.24	91.42	1919
H5b: Economic performance	4,451	13	0.361	0.262	0.447	7.178	0.000	139.89	91.42	2002
H5c: Environment performance	2004	07	0.272	0.151	0.389	4.360	0.000	45.045	86.68	222
H5d: Social performance	478	01	0.383	0.553	0.673	9.185	0.000	23.45	0.234	–

Table 3.
Results of meta-analysis

Note(s): Correlation significant at two-tailed; K (effect sizes); *N* (observations); rz (standardized correlations coefficient)
Source(s): Authors' own creation

Llopis and Segarra-Blasco, 2018), our aggregate results show that the positive view of the eco-innovation/sustainable performance relationship dominates the neutral and negative findings.

Furthermore, the disaggregate findings suggest that SMEs` eco-innovation programs correlate more with social performance ($r = 0.580$, $p = 0.000$) than with environmental performance ($r = 0.421$, $p = 0.000$) and economic performance ($r = 0.371$, $p = 0.000$). This shows that eco-innovation strategies appear to substantially influence the "soft" performance measures like firm reputation, customer satisfaction, and improvement in the quality of life of employees and community.

Moreover, the disaggregate results demonstrate that eco-organizational innovations exert a more substantial effect on SMEs' sustainable performance ($r = 0.422$, $p = 0.000$) than eco-process innovation ($r = 0.405$, $p = 0.000$), eco-product innovation ($r = 0.349$, $p = 0.000$), and eco-marketing innovation ($r = 0.314$, $p = 0.000$). Therefore, SMEs endeavors toward restructuring, renewing, and redesigning organizational procedures, systems, or routines to generate eco-innovation tend to substantially enhance their sustainable performance (Geng *et al.*, 2021; Setyawati *et al.*, 2020).

4.2 Eco-product innovation and SMEs' sustainable performance

The findings show a significantly moderate and positive association between eco-product innovation and sustainable performance ($r = 0.349$, $r = 0.000$). We also discovered that SMEs' eco-innovations in products correlate strongly with social performance ($r = 0.501$, $p = 0.000$) but moderately with environmental performance ($r = 0.370$, $p = 0.000$) and economic performance ($r = 0.292$, $p = 0.000$). SMEs' ability to optimize their resource features to make a product simpler to reuse, decompose or recycle (Singh and Chakraborty, 2021) can enhance social performance aspects (Mishra *et al.*, 2019). Thus, the more SMEs commit to developing and producing eco-sustainable products, the higher their social performance in terms of reputation, customer relationships, etc.

4.3 Eco-process innovation and SMEs' sustainable performance

The meta-analysis findings reveal a significantly positive and moderate relationship between eco-process innovation and SMEs' sustainable performance ($r = 0.405$, $p = 0.000$, H2). In particular, eco-process innovation relates more strongly with environmental performance ($r = 0.467$, $p = 0.000$, H2a) than with economic performance ($r = 0.381$, $p = 0.000$, H2b) and social performance ($r = 0.187$, $p = 0.000$, H2c). Ranging from 0.187 to 0.467 within a 95% confidence interval, the notable effect size of the eco-process innovation/sustainable performance relationship shows that eco-innovation in the process helps SMEs to minimize consumption of hazardous materials, undertake environmental audits, reduce the negative environmental impact, accidents, emissions, and waste (Maroufkhani *et al.*, 2020; Khoja *et al.*, 2022). However, eco-process innovation shows a weaker effect on social performance than the other three types of eco-innovation, which means that a firm`s investment in the eco-efficiency process does not strongly correlate with performance indicators like reputation or customer relationship.

4.4 Eco-organizational innovation and SMEs' sustainable performance

Our meta-analysis finding shows an overall positive and moderate eco-organization innovation/sustainable performance nexus ($r = 0.422$, $p = 0.000$). Compared to the other types of eco-innovation, eco-organizational innovation has the strongest effect on the sustainable performance of SMEs. These findings demonstrate that SMEs can significantly increase sustainable performance (Baeshen *et al.*, 2021) by promoting eco-innovations in their organizational structures and systems through ameliorating workplace satisfaction,

minimizing transaction and administrative costs, or plummeting the cost of supplies. On the disaggregate impact on each sustainable performance dimension, results show that sustainable performance of eco-organizational innovation is more strongly correlated with social performance ($r = 0.631$, $p = 0.000$) than with economic performance ($r = 0.372$, $p = 0.000$) and environmental performance ($r = 0.361$, $r = 0.000$). This is contrary to findings that eco-organizational innovations do not affect economic performance (Sáez-Martínez *et al.*, 2014) and environmental performance (Kim *et al.*, 2021; Shin and Cho, 2022).

4.5 Eco-marketing innovation and SMEs' sustainable performance

Our meta-analysis findings show a significantly positive and moderate relationship between eco-marketing innovations and SMEs` sustainable innovation ($r = 0.314$, $p = 0.000$). This indicates that the adoption of a green promoting strategy improves stakeholders' fulfillment and expands customer loyalty, which can enhance the social, economic, and environmental performance of SMEs (Geng *et al.*, 2021; Alraja *et al.*, 2022). Compared to the other three types of eco-innovations, eco-marketing innovation has the weakest effect on sustainable performance. One possible reason for this finding is the problem of greenwashing, which happens when the public perceives the green marketing promotions of firms as unauthentic and ungenuine. This may, of course, affect the patronage of firms' goods and services and, ultimately, performance.

4.6 Moderator analysis

Tables 4 and 5 show the subgroup analysis and meta-regression analysis results, respectively, of the moderating effects of industry types, country economic development, culture, global sustainable competitive index, study type, sampling technique, and publication status.

Concerning industry types, both our subgroup and meta-regression findings reveal notable moderating effects on the magnitude of the eco-innovation/sustainable performance association: SMEs in the service sector have a much more substantial nexus ($r = 0.493$, $p = 0.000$) than those in the manufacturing sector ($r = 0.422$, $p = 0.000$), and agriculture ($r = 0.211$, $p = 0.000$) (ß $= 0.297$, $p = 0.092$). This means that service firms implementing eco-innovations tend to improve their social, economic, and environmental performances more than manufacturing and agriculture firms. One likely reason could be the increasing utility margins of eco-innovations in the service sector due to their minimum negative impact on the environment compared to manufacturing firms.

Moreover, SMEs in developed economic markets with high HDI that implement eco-innovations tend to achieve better sustainable performance ($r = 0.418$, $p = 0.000$) than their counterparts in developing economic markets with low HDI ($r = 0.412$, $p = 0.000$) (ß $= -0.378$, $p = 0.078$). A possible reason is that SMEs in developed economies possess superior innovation infrastructures, human capital, and financial resources for companies to exploit, develop and execute several eco-innovation strategies than in developing markets (Sarasini *et al.*, 2014).

Also, our analysis surprisingly reveals that SMEs' eco-innovation practices in countries with low GSCI tend to have higher sustainable performance ($r = 0.439$, $p = 0.000$) than those in countries with high GSCI ($r = 0.385$, $p = 0.000$). The meta-regression supports this finding (ß $= 0.175$, $p = 0.024$). This contradicts our assumption that SMEs in countries with high GSCI will achieve better sustainable performance than SMEs in low GSCI countries. One possible reason could be that SMEs in economies with high GSCI may have reached the tip of the production curve and, hence, may be realizing diminishing utility margins/returns from eco-innovation programs. Another reason could be that these SMEs experience high competition from firms adopting similar eco-innovation programs or making similar considerable investments in eco-innovations. On the contrary, SMEs in countries with low

	N	K	rz	−CI	+CI	Z	*p*	Q	I-S	FSN
Contextual factors										
Industry types										
Agriculture	969	05	0.211	0.041	0.371	2.454	0.014	29.34	86.37	58
Manufacturing	32,029	142	0.442	0.372	0.502	11.235	0.000	7839.20	98.20	9713
Service	3,005	10	0.493	0.141	0.734	2.668	0.008	1052.63	99.14	2,221
Mixed	98,838	76	0.364	0.311	0.413	12.982	0.000	3539.34	97.88	1,594
Country development										
High HDI	47,964	181	0.418	0.365	0.469	13.833	0.000	8742.09	97.94	9345
Low HDI	12,238	50	0.412	0.309	0.505	7.241	0.000	2155.80	97.73	10,370
Global sustainable competitive index (GSCI)										
High GSCI	22,739	97	0.385	0.318	0.447	10.45	0.000	3194.99	97.00	13,610
Low GSCI	37,463	134	0.439	0.374	0.500	11.88	0.000	7677.23	98.27	19,169
Culture-Individualism										
High IDV	3,216	13	0.405	0.130	0.622	2.816	0.005	855.42	98.60	1953
Low IDV	56,986	218	0.417	0.370	0.463	15.434	0.000	10042.9	97.84	8,594
Industry intensity										
High tech	28,240	121	0.404	0.3314	0.4712	10.035	0.000	6009.16	98.00	3,131
Low tech	9152	33	0.521	0.3715	0.6438	6.044	0.000	2627.21	98.78	4,737
Mixed	97,449	79	0.381	0.3272	0.4330	12.707	0.000	4137.09	98.11	2,205
Method factors										
Sampling technique										
Non-probabilistic	6,619	34	0.349	0.272	0.422	8.356	0.000	389.38	91.52	6,818
Probabilistic	128,222	199	0.424	0.380	0.467	16.661	0.000	13731.75	98.56	7238
Publication status										
Published	69,559	225	0.411	0.360	0.459	14.436	0.000	13593.47	98.35	14,252
Unpublished	65,282	08	0.495	0.334	0.628	5.444	0.000	300.90	97.67	4,189
Study type										
Cross-sectional	57,511	225	0.42	0.37	0.47	15.48	0.00	10554.17	97.88	8,629
Longitudinal	77,330	08	0.22	0.05	0.38	2.55	0.01	1394.39	99.50	1,292

Source(s): Authors' own elaboration

Table 4. Results of contextual and method moderators

GSCI may be enjoying increasing utility margins due to the initial phase of eco-innovation adoption, high government incentives and subsidies, and low competition from competing firms due to the limited number of firms with sufficient resources to adopt eco-innovation (Blagova and Korkova, 2018).

Furthermore, our findings demonstrate that SMEs operating in collectivist cultures achieve better sustainable performance ($r = 0.417$, $p = 0.000$) than those operating in individualistic cultures ($r = 0.385$, $p = 0.000$). The meta-regression supports this, albeit showing a low effect (ß = 0.409, $p = 0.092$). A possible explanation for this finding is that eco-innovation programs are sometimes seen as a shared and collective initiative that promotes the collective good of society; hence, SMEs adopting this program are seen as good citizens, which, in turn, leads to higher patronage of their products and services. Therefore, our finding disagrees with the view that individualistic cultures are more likely to protect the environment due to their personal motives, like social status (Bitencourt *et al.*, 2020).

	Coefficient	Standard error	LCI	UCL	Z	*p*	r2
Contextual moderators							
Industry type (0 = manufacturing; 1 = service)	0.297*	0.180	0.055	0.650	1.656	0.092	0.097
Country development (0 = low HDI; 1 = high HDI)	−0.378*	0.219	0.043	0.816	−1.76	0.076	0.074
GSCI (0 = high GSCI; 1 = low GSCI)	0.175**	0.077	0.023	0.327	2.261	0.024	0.167
Culture (0 = individualism; 1 = collectivist)	0.409*	0.243	0.063	0.885	1.689	0.092	0.089
Industry intensity (0 = high; 1 = low)	0.183**	0.087	0.014	0.354	2.09	0.032	0.180
Methodological moderators							
Sampling technique (0 = Non. Prob; 1 = prob)	0.208**	0.075	0.055	0.350	2.69	0.007	0.098
Publication status (0 = published; 1 = unpublished)	0.222	0.157	−0.086	0.531	1.42	0.157	–
Study type (0 = cross-sectional; 1 = longitudinal)	−0.105	0.175	−0.454	0.239	−0.601	0.548	–

Table 5.
Meta-regression (MARA)

Note(s): *p\0.1/; **p\0.05; ***p\0.001
Source(s): Authors' own creation

Finally, the meta-analysis results show surprisingly that SMEs in the low-tech industry that adopt eco-innovations achieve better sustainable performance ($r = 0.521$, $p = 0.000$) than those in the high-tech industries ($r = 0.404$, $p = 0.000$) (ß = 0.183, $p = 0.032$). One possible explanation could be that low-tech firms are more likely to invest in eco-innovations because of their greater need for operational efficiency and business model innovations.

As for the methodological moderators, we find that studies using probabilistic sampling achieve higher effect sizes ($r = 0.424$, $p = 0.000$) than those adopting non-probabilistic sampling ($r = 0.349$, $p = 0.000$). Contrary to the current literature thinking that significant and positive effect sizes publish faster than non-significant studies, our findings show that even unpublished papers produce larger effect sizes ($r = 0.495$, $p = 0.000$) than published papers ($r = 0.411$, $p = 0.000$). Finally, we found that cross-sectional studies produce larger effect sizes ($r = 0.420$, $p = 0.000$) than longitudinal studies ($r = 0.220$, $p = 0.000$).

5. Robustness tests

Following suggestions of previous meta-analyses in the innovation and management literature (Liu *et al.*, 2023), we conducted some robust checks to ascertain the symmetry and reliability of our data.

First, we employed Fail-Safe N (FSN) and funnel plot to assess the publication bias of our aggregate findings. Based on the test results of the FSN, we conclude that there is no issue of publication bias since the minimum value of the FSN is greater than the critical value of 5*K+10 (5*233 + 10), where K is the number of effect size in each subgroup. However, for the eco-marketing innovation/social performance nexus, the FSN results are not specified because of the scarcity of effect sizes. In this regard, we suggest that future studies throw more light on the nexus between eco-marketing innovation and social performance. Moreover, the funnel plot (shown earlier in Figure 3) shows that effect sizes are scattered in the shape of a funnel symmetrically around the average overall estimated effect. Furthermore, we checked for outliers in the effect sizes by plotting the distribution of the

effects. Our test shows that the distribution is symmetrical, and the distribution of the mean effect sizes does not have more than two standard errors above or below the effect size (Rosenbusch *et al.*, 2019). In addition, we followed Huffcutt and Arthur's (1995) approach to calculate the sample-adjusted meta-analytic deviancy statistics to assess the influential effect of large sample sizes on findings. Lastly, we checked whether our results held if we employed the number of effect sizes instead of the observations as the sample size.

6. Discussion and conclusion

With the ever-increasing concerns over climate change and environmental consequences of the operations of businesses, coupled with the pressure from the government and marketplace regarding sustainability, the nexus between eco-innovation and sustainable performance has garnered tremendous interest from scholars and practitioners over the last decade. Nevertheless, discrepancies across multiple studies from different contexts and disciplines lead to mixed results, contributing to managers' uncertainty about the performance effects of eco-innovation investments. To generalize informative conclusions from the mixed findings and fragmented studies, we carry out a meta-analytic review of SMEs' eco-innovation/sustainable performance. We comprehensively map out the eco-innovation/sustainable performance links by integrating 99 primary studies with 233 effect sizes from 2006–2022 by identifying four distinct types of eco-innovation (eco-product, eco-process, eco-organizational, and eco-marketing innovations).

The results reveal significantly positive and moderate effect of eco-innovation on the sustainable performance of SMEs concerning economic, environmental, and social performances. Thus, from the RBV and DCT, SMEs can secure unique resources and capabilities that contribute to their innovation process and enhance their sustainable performance by integrating eco-innovation programs. As Afum *et al.* (2021) proposed that eco-innovation can enhance SMEs' advantages of effectiveness and efficiency, our results further stimulate more confidence in implementing eco-innovation in SMEs by revealing each practice in depth. While implementing eco-innovations into business processes is capital-intensive and complicated, SMEs could benefit from boosting reputation, environmental efficiency, sales and returns, customer satisfaction, and reducing operational costs (Le and Ikram, 2022; Madaleno *et al.*, 2020).

Moreover, our findings show that eco-innovations in SMEs are strongly correlated with social performance. This finding advances theories on social change and institutional development concerning the social impact of eco-innovation by showing that eco-innovation is strongly associated with the "humanistic side" of stakeholder management – reputation/image, improvement in employee safety and health, the quality of life of the community and work conditions. Furthermore, eco-organizational innovation stands as the eco-innovation dimension that substantially influences sustainable performance, demonstrating that SMEs' orientations toward restructuring, renewing, and redesigning organizational procedures, systems, or routines to generate eco-innovation can enhance their sustainable performance prospects. The dimension with the lowest effect is eco-marketing innovations, which could be partly due to the problem of greenwashing, which leads the public to perceive the green marketing promotions of firms as unauthentic and ungenuine.

Furthermore, we conduct moderator analysis to explore five contextual factors that moderate the magnitude of the eco-innovation/sustainable performance nexus, namely industry/sector, human development index, global sustainable competitive index, and culture. Remarkably, research in the service sector (versus manufacturing, agriculture) in developed countries (versus developing economies), in collectivist cultures (versus individualistic cultures), and in countries with low GSCI (versus high GSCI) could produce a much stronger eco-innovation/sustainable performance nexus. These findings are crucial to

explain the discrepancies in the different contexts and offer a comprehensive overview of the eco-innovation/sustainable performance nexus pragmatically and theoretically.

7. Implications

7.1 Theoretical implications

The meta-analysis and its findings make the following theoretical contributions. First, the study extends the application of the RBV and DCT theories to the sustainability domain, allowing for the generalization and replicability of the frameworks. Second, our meta-analysis synthesizes the fragmented studies across journals, cultures, and disciplines to clarify the mixed findings on how and to what degree eco-innovation affects SMEs` sustainable performance. Third, our focus on sustainable development as a dependent variable is theoretically enhancing as it departs from the conventional norm of measuring performance via financial and non-financial indicators, thereby offering scholars a new perspective on performance measurement. Four, the findings of the review elucidate the distinct nexus between identified eco-innovation practices of SMEs and each sustainable performance measure. Decoupling eco-innovation into its distinctive archetypes and examining their relationship with different performance dimensions allows for accurate estimation of the eco-innovation/sustainable performance links and offers a holistic understanding of the eco-innovation behavior of SMEs worldwide. More specifically, eco-innovation practices in SMEs have a more substantial aggregate effect on social performance than environmental and economic performance aspects, which advances social change theories and humanistic perspectives of sustainability. In addition, eco-organization innovation of SMEs has a more substantial impact on sustainable performance than eco-product, eco-process, and eco-marketing innovations. This offers a distinctive perspective on the disaggregate effects of eco-innovation in SMEs and allows for developing specific organizational and performance theories. Moreover, our focus on a specific context, SMEs, contributes to the theories on context dependency of innovation by showing the dynamics of eco-innovation practices in SMEs since these firms innovate differently than their large counterparts. Furthermore, our assessment of contextual and methodological factors on the eco-innovation/sustainable performance nexus addresses the context-sensitive front of eco-innovation and firm performance. It sheds valuable insight into the boundary-spanning conditions that may promote or impede the eco-innovation/sustainable performance nexus, thereby offering some key answers to the "why" of the mixed results in the field. Finally, our study`s findings provide a research agenda for further studies.

7.2 Managerial and policy implications

The findings of the meta-analysis also provide numerous managerial implications. First and foremost, the results that eco-organizational innovations have the most significant influence on sustainable performance demand that SMEs implement eco-organizational mechanisms, structures, and systems to produce structural and managerial renewal in the firm's activities. One practical way to accomplish this is to build eco-infrastructure and eco-organizational structures and systems that encourage and reward eco-organizational members. Again, managers must modify the firm`s management processes by devising the strategy and structure of units and tasks (e.g. new product management and development systems, new enterprise resource planning systems, etc.).

SME managers/CEOs must also consider the joint and relative gains and limitations of each archetype of eco-innovation by developing, implementing, and evaluating eco-innovation practices based on specific performance objectives. For instance, our findings inform CEOs/managers that eco-innovation relates more to social performance. Thus, CEOs

of SMEs that seek to improve their reputation, customer satisfaction, employee health and safety, quality of life of community and employees, etc. can launch eco-innovation initiatives. Likewise, when striving to improve environmental performance, because our findings show that eco-process has the most substantial impact on environmental performance, SMEs could focus on eco-process innovation. One practical way to do this is by using additive solutions, cleaner production technologies, fewer resources, managing non-product output, and redesigning the operation activities in the value and supply chain. In addition, our findings inform CEOs/managers of SMEs about the need for strategic orientation and resource allocation. For instance, more resources and attention could be devoted to eco-organizational innovation. When the organizational structures, systems, and procedures become ecological, the processes, products, and marketing would become ecological as well. Systems affect processes; thus, CEOs of SMEs should pay more attention to eco-organizational innovation, and this can lead to the development of other types of eco-innovation. To do this, the CEOs of SMEs must establish a sustainability vision, develop employee environmental development and training, build a stakeholder management system, and promote employee engagement in sustainability activities.

Our moderator analysis also offers pragmatic insights for CEOs/managers of SMEs. First, managers must implement eco-innovation strategies by considering their sectoral/industrial aspects. For example, SMEs in the service sector can produce better returns from eco-innovation investments. Thus, SMEs in the service sector can use eco-innovation programs as a "success-inducing approach" and those in the manufacturing sector as a "failure-prevention" approach. Put another way, service SMEs can employ eco-innovation as a competitive advantage, while manufacturing SMEs should use eco-innovation to survive. Likewise, SMEs operating in collectivist societies may yield better sustainable performance when implementing eco-innovation programs. One practical way to achieve this is by developing green products and marketing campaigns and promoting them through exhibitions, press releases, advertising campaigns in such cultures, etc. since people in these societies recognize firms' sustainability efforts and reward them accordingly. Moreover, SMEs in developed economies can inspire SMEs in emerging economies to adopt eco-innovations efficiently and effectively by illustrating significantly rewarding experiences in developed countries. Furthermore, The CEOs of SMEs must establish a sustainability vision, develop employee environmental development and training, build stakeholder management systems, and promote employee engagement in sustainability activities.

The findings of the study also offer policymakers a roadmap concerning harnessing and promoting environmental regulations and mechanisms to ensure the development of sustainable eco-innovation initiatives in the industry. The scarcity of resources would restrict the development of environmental management in SMEs. Thus, appropriate environmental regulations can enforce and motivate SMEs to adopt eco-decisions and eco-strategies that enhance environmental productivity and resource efficiency. The meta-analysis results show that a successful eco-innovation initiative demands a holistic approach. For instance, the government can implement administrative support to SMEs should be merely funding but appropriate training on how to develop eco-organizational innovation (structures, systems, routines). Finally, the government can offer education and training programs to create awareness and to get CEOs of SMEs well-informed about the relevance of adopting eco-innovation programs in their strategic innovation. One conceivable way is to organize stakeholder meetings and seminars on eco-innovation in SMEs through government-industry collaborations.

8. Limitations and directions for future research

Analogous to all meta-analyses, this study also has some limitations, which provide avenues for future research. First, while our analysis combines the meta-correlation analysis model with a

meta-regression model to generalize the findings, we do not account for causality. Thus, our research does not allow for the analysis of mediating effects. To this end, we suggest that future studies employ METASEM (meta-structural equation modeling) to examine factors like ambidexterity, entrepreneurial orientation, supply chain efficiency, and innovation capability that may account for causal effects in the eco-innovation/SME sustainable performance links. Second, our study is limited to only the SME sector, which affects our generalizability to the large industry. Therefore, we recommend that future studies examine the eco-innovation practices of large enterprises by replicating our meta-analytic framework to allow for cross-context comparison. Furthermore, we have focused on the sustainable performance effects of eco-innovation programs in SMEs, but future studies could parse the outcomes into financial and non-financial performance. In addition, our moderator variables are not exhaustive. Future studies can examine other moderators like firm age, business context (B2B vs. B2C), firm orientation (profit vs. not-for-profit), and different cultural dimensions of Hofstede`s model (e.g. long-term orientation, power distance). Likewise, new method moderators like performance measures (accounting vs. marketing measures), theory use (atheoretical vs. theoretical), and sample size (large vs. small) could be tested. Finally, our findings failed to support our assumption that research in the manufacturing sector could yield a robust eco-innovation/sustainable performance nexus than those in the service sector. Therefore, it would be interesting for future research to examine why specific sectors can secure more performance gains from eco-innovation adoption than others. Related to this, future studies could probe why SMEs in the low-tech industry and in countries with low GSCI perform better than high-tech SMEs and those in countries with high GSCI.

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