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The process supporting the emergence of the environmental innovation capabilities within small businesses: An empirical investigation

Giovanna Ferraro[1] | Renato Passaro[2] | Ivana Quinto[2] | Antonio Thomas[3]

[1]Department of Enterprise Engineering, University of Rome Tor Vergata, Rome, Italy

[2]Department of Engineering, University of Naples Parthenope, Naples, Italy

[3]Department of Business and Economics, University of Naples Parthenope, Naples, Italy

Correspondence
Giovanna Ferraro, Department of Enterprise Engineering, University of Rome Tor Vergata, Via del Politecnico, 1-00134 Rome (RM), Italy.
Email: giovanna.ferraro@uniroma2.it

Ivana Quinto, Department of Engineering, University of Naples Parthenope, Centro Direzionale Is. C4-80143 Napoli (NA), Italy.
Email: ivana.quinto@uniparthenope.it

Funding information
Università degli Studi di Napoli Parthenope; University of Naples Parthenope

Abstract

For several years, companies have made strategic changes to align with sustainable development principles by developing eco-innovations. While research consistently highlights the positive impact of eco-innovations on organisational performance, the factors driving these initiatives—particularly within small and medium-sized enterprises (SMEs)—remain less clear. This inconsistency is due to the heterogeneity of SMEs and their high sensitivity to external contexts. To address this issue, our study delves into the role of competencies, technological factors and networking in shaping the environmental innovation capabilities of a homogeneous SME population in terms of sector, age, size, legal status, geographical location and orientation towards innovation. Using the partial least squares approach, we find that competencies and technological factors are the key drivers of eco-innovation, while networking shows no significant effect. These findings contribute to the existing literature by underlining the fundamental importance of internal skills and technological adoption for fostering eco-innovation. They also suggest that networking becomes essential in environments lacking robust public and private support mechanisms for SME growth. Considering the rapid and turbulent changes, driven by the dual needs of sustainability and competitiveness, our results offer useful and critical advice for policymakers to define more appropriate and effective policies.

KEYWORDS
eco-innovations, Gaussian copula approach, innovation capabilities, networking, PLS-SEM methodology, SMEs

Abbreviations: AVE, average variance extracted; EICs, eco-innovation capabilities; GC, Gaussian copula; PLS-SEM, partial least squares structural equations modelling; R&D, research and development (R&D); SEM, structural equation modelling; SME, small and medium-sized enterprise.

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1 | INTRODUCTION

In today's ever-changing economic environment—influenced by changing customer behaviours, rapidly evolving technologies and pressing competition and demographics—companies must constantly innovate to maintain their competitive advantage. Adopting innovative behaviours involves the need to develop one's awareness of innovation as well as improving one's set of skills, resources and tools while understanding the emerging opportunities and challenges deriving from sustainable development. From this perspective, this study proposes an investigation into a category of companies that potentially offer an important contribution to their country in the transition towards cutting-edge activities and in maintaining their competitiveness. This study also looks at innovative small and medium-sized enterprises (SMEs) with the capacity pursue those innovations compatible with the needs of sustainable development.

Since the publication of the Brundtland Report, which introduced the concept of *sustainable development* on a global scale, the numerous principles (the Sustainable Development Goals, corporate social responsibility, environmental, social and governance, etc.) that emerged at the international level have guided institutions and companies towards environmentally and socially responsible actions and behaviours. Scholars (Bos-Brouwers, 2010; Dangelico et al., 2017; Darmandieu et al., 2021) agree that the main path to pursuing these principles lies in the adoption of wide-ranging innovations commonly labelled as environmental or eco-innovations. Such eco-innovations are considered ‘any form of innovation aiming at significant and demonstrable progress towards the goal of sustainable development, through reducing impacts on the environment or achieving a more efficient and responsible use of natural resources, including energy’ (EU, 2007). As a result, a flourishing stream of research has focused on identifying the drivers or determinants that encourage companies to invest in eco-innovations.

Previous research findings show that, on the external side, regulations requiring companies to pursue sustainable development and public financial incentives represent two of the most influential antecedents stimulating eco-innovations among SMEs (e.g. Carfora et al., 2021; Castellano et al., 2022). Furthermore, pressure from customers and suppliers also plays a fundamental role in steering SMEs towards eco-innovations (Jun et al., 2019; Thomas et al., 2020). A third influential antecedent concerns the technological drive linked to the presence of an adequate knowledge background in the external context (e.g. Valdez & Castillo-Vergara, 2021). On the internal side, certain relevant aspects can be recognised, such as the competencies and specific skills of SMEs' employees (e.g. Handrito et al., 2021), their sensitivity towards sustainability issues (Xavier et al., 2017) and the presence of a research and development (R&D) function activities (e.g. Demirel & Kesidou, 2019). Additionally, the goal of achieving better economic performance and profitability has, in many circumstances, proved to be a powerful antecedent (Hervás-Oliver et al., 2021).

However, the existing literature has not always produced uniform and consistent outcomes. The primary reason for this is that the determinants identified and tested until now are numerous in volume. They affect eco-innovations and interact with one another in different ways, change in importance over time and differ in nature (e.g. structural variables, innate personal traits, experiences and contextual factors), making simultaneous statistical validation challenging (Crossley et al., 2021; Zartha Sossa et al., 2020). The situation is even more complex for SMEs, given their heterogeneity in structural variables, their higher sensitivity to external factors and the presence of more direct decision-making processes (Heras-Saizarbitoria et al., 2016; Martinez-Ros & Kunapatarawong, 2019; Melander, 2018). Even the tools used to examine large companies often do not suit SMEs (Adomako et al., 2021; Zubeltzu-Jaka et al., 2018).

In order to tackle these issues, another analysis perspective appears to be necessary. In particular, it could be beneficial to adopt an analysis perspective that focuses on the process that generates the awareness to invest in eco-innovation, rather than the endowment of specific tangible or intangible resources to a dichotomous variable whose presence allows the company to pursue eco-innovations (da Silva Nascimento et al., 2023; Singh et al., 2021; Zahoor & Gerged, 2021). We refer to *eco-innovation capabilities* (EICs), that is capabilities specifically dedicated to the development (or improvement) of new (or existing) products, processes, organisational structures and technologies that reduce pollution and environmental risks (Demirel & Kesidou, 2019; Fong & Chang, 2012; Kabongo & Boiral, 2017; Tseng et al., 2019).

Rather than being a static collection of factors related to possessing specific resources, skills or capabilities, EICs reflect a company's growing recognition of the opportunity to systematically pursue eco-innovations and the need for ongoing investment in dedicated tools. EICs emerge from the dynamic interplay between corporate experiences, the effectiveness of organisational models, internal skills and competencies, investments in knowledge and technology and the company's ability to engage with external partners (DiBella et al., 2022; Handrito et al., 2021).

Currently, the literature concerning this approach among SMEs needs further deepening due to the limited research (Carfora et al., 2021; Tang et al., 2018) and the ambiguous outcomes; a situation most likely deriving from the fact that such studies do not consider the significant heterogeneity of SMEs.

Our study aims to address this knowledge gap by examining the processes fostering the emergence of EICs among SMEs.

To mitigate the above-mentioned limitations of previous investigations, we examine a sample of SMEs with a high degree of homogeneity in terms of structural variables (age, legal form, size, sector of activity and geographical location), innovation orientation, ownership (teams of young entrepreneurs with high educational levels), territorial context and public support received.

By minimising the influence of territorial context and the heterogeneity of SMEs, our intent is to obtain more reliable results that could be useful to other categories of SMEs and policymakers. We also believe that innovative SMEs (the subject of our research) are of particular interest due to their high potential to contribute to territorial development and the transition to advanced industrial models (Passaro et al., 2023; Taipale-Erävala et al., 2019; Yang, 2017).

In short, the aim of this study is to verify how some antecedents affect the emergence of EICs within a homogeneous sample of SMEs that exhibit a high orientation towards innovations in general. To this purpose, we estimate a structural equation model using the partial least squares (PLS) approach, based on responses from the selected SMEs, collected through a devoted questionnaire. This model considers three basilar antecedents of innovation processes: competencies, technological factors and networking (e.g. Janahi et al., 2022; Lozano, 2023; Seyedesmaeil et al., 2018). We focus on these well-delineated antecedents to minimise the mentioned mutual influence existing among determinants of eco-innovations, thereby enhancing the validity of this investigation.

Additionally, our contribution explicitly accounts for the endogeneity of innovation processes and their antecedents by adopting the Gaussian copula approach (Gilson, 2010; Zaefarian et al., 2017. Applying such an approach, we identified and corrected for endogeneity in the relationships between key variables (competencies, technological factors and networking) and EICs. This correction is crucial for preventing improper inferences and ensuring our estimates of the factors' impact on EICs are accurate and reliable, reflecting true causal effects rather than spurious correlations.

The paper is organised as follows: Section 2 describes the theoretical background, Section 3 introduces the proposed hypotheses, Section 4 explains the method used, Section 5 shows the results obtained, Section 6 presents the discussion of the results, and Section 7 outlines the conclusions by describing the theoretical and managerial implications and offering suggestions for further development of the research.

2 | THEORETICAL BACKGROUND

The described concept of EICs arises from the merging of two types of capabilities; as such, its typical plural usage is not coincidental. The first category revolves around *innovation capabilities*, long acknowledged by scholars (e.g. Aas & Breunig, 2017; Breznik & Hisrich, 2014; Daronco et al., 2023) as pivotal for enhancing company performance and increasing productivity and competitiveness. Researchers also underline that there are several different definitions of innovation capabilities, with no clear distinction made against other types of capabilities such as *absorptive* and *dynamic* capabilities (Kabongo & Boiral, 2017; Mendoza-Silva, 2021; Teece, 2007).

Initiating an innovation process is a complex activity. Doing so presupposes a multiplicity of further skills that concern both purely technical and technological aspects relating to the implementation of innovations. This includes the ability to (i) organise and manage research teams and work, (ii) delegate activities, (iii) adapt the production structure and (iv) procure adequate financial and human resources to support the processes started. Logically speaking, the innovation capabilities should also include Kirzner's opportunity discovery capability, without which no exploitation process could ever take place. We can thus ascertain that, within their broad scope, innovation capabilities tend to include the *dynamic capabilities* related to the organisation's ability to adapt, integrate and reconfigure its resources and capabilities in response to changing market conditions and opportunities (Breznik & Hisrich, 2014; Dangelico et al., 2017), rather than distinguishing themselves from them. Similarly, innovation capabilities also include the *absorptive capacities* related to the firm's ability to recognise the value of new information, assimilate it and apply it to commercial ends (Pacheco et al., 2018; Scuotto et al., 2017).

The second category of capabilities supporting EICs pertains to *environmental management*, a concept that is becoming increasingly indispensable for sustainable development goals worldwide. Although business and management literature has not yet conclusively determined whether adherence to sustainability criteria represents mainly a cost or an opportunity for companies, some leading authors (e.g. Ambec & Lanoie, 2008; Porter & van der Linde, 1995) have suggested that integrating environmental management practices enhances competitiveness. Companies striving for sustainable behaviours are spurred to apply innovations in environmental management. In so doing, they gain such advantages as enhanced market presence, premium pricing for green products, incentives and benefits from public bodies, a better image, entrance into new markets and so on. All these elements positively affect the economic and financial performance. Thus, the proactive adoption of eco-innovation could directly improve both environmental and financial performance. The environmental management orientation becomes a true strategy when companies (i) habitually experiment with new green ideas, (ii) systematically seek more sustainable ways to do things, (iii) are creative with green efforts regarding management and operational processes and (iv) strive to be the first to market new ecological products and services. Furthermore, for such companies, the environmental requirements associated with processes, products and services tend to be more rigorous than those of competitors in that they go beyond environmental regulations (Ko & Liu, 2017; Lee & Klassen, 2016).

By integrating these two categories of capabilities, EICs can be viewed as dynamic and absorptive organisational capabilities through which companies can develop sustainable solutions that meet current and future customer needs, pursue operational efficiency through resource deployment and create value by mastering existing technologies and innovating new ones (daronco et al., 2023; Melander, 2018; Sukri et al., 2023). Thus, EICs represent a strategic lever of competitive advantage and better economic performance via a "win–win" situation in which both environmental sustainability and economic benefits increase due to the positive spill-over effects of eco-innovations (Dangelico et al., 2017; Kabongo & Boiral, 2017; Nguyen & Adomako, 2021).

Although EICs allow companies to restructure or modify portfolios of tangible and intangible assets, enabling them to capitalise on the opportunities coming from the markets, the processes through which EICs emerge and develop differ according to the features characterising the companies (Aas & Breunig, 2017; Heras-Saizarbitoria et al., 2016). For instance, compared to large businesses, SMEs usually show higher dynamism and internal flexibility, and are characterised by lower bureaucracy, which allows for rapid decisions to be made. Subsequently, SMEs tend to react more quickly to market requirements and are more responsive to changing circumstances (Demirel & Kesidou, 2019; DiBella et al., 2022). Conversely, the complexity of new technologies and the uncertainty in technological development makes SMEs more vulnerable to environmental forces. Additionally, SMEs traditionally suffer from reduced financial resource availability (and the capacity to attract them) and limited capabilities able to identify and utilise external sources of knowledge, and scientific and technological expertise (Zahoor & Gerged, 2021; Zahoor & Lew, 2021). Thus, SMEs tend to engage in product and process improvement rather than radical or new technological developments (Faccin et al., 2020; Melander, 2018).

In this context, it is difficult to detect the specific factors that allow SMEs to pursue EICs as a business strategy (DiBella et al., 2022; Zahoor & Lew, 2021). The current research on the emergence of EICs among SMEs is still in its infancy (Carfora et al., 2021; Passaro et al., 2023). To date, efforts to build a comprehensive approach regarding EICs in SMEs are hampered by the fact that, for SMEs, the pursuit of eco-efficiency is not perceived as an element able to increase competitiveness but rather a simple cost (Darmandieu et al., 2021; Kabongo & Boiral, 2017).

By considering these complexities and uncertainties, this paper takes into account only three antecedents of EICs: *competencies*, *technological factors* and *networking*. These three antecedents are among the most discussed by previous investigations.

3 | THE HYPOTHESES

3.1 | Competencies

For many decades, researchers have studied the elements that influence the innovation capabilities of companies. These elements include the set of skills, abilities, knowledge and attributes necessary to drive and manage innovation effectively within an organisation. In this research, we consider innovation capabilities (including skills and competencies) as referring to abilities, skills, technical knowledge and soft skills (i.e. relational and behavioural capabilities) that characterise the way in which companies interact with the market and its players. It is worth noting that having a diverse mix of abilities and skills fosters the generation of innovative ideas and creative collaboration; doing so is crucial to compete in the markets and to differentiate the company from competitors.

Typical examples of these skills, abilities and competencies are adaptability and flexibility, creative thinking, customer-centricity, leadership, open-mindedness, problem-solving, risk-taking, teamwork, technical knowledge and strategic thinking. These elements enable individuals and teams to generate, develop and implement new ideas, leading to improved processes, products or services (e.g. Glover et al., 2016). They become also part of the organisational culture, crucial for fostering a culture of innovation and ensuring that a company remains competitive in a rapidly changing market. Moreover, these skills allow companies to integrate, build and reconfigure internal and external processes by redesigning strategies and identifying new opportunities, and by managing them profitably (Wiredu et al., 2024).

The level of innovation within a firm is also linked to specific processes adopted by the company, such as idea generation, the adoption of suitable management systems and effective project management tools (Malesios et al., 2018). These innovation processes involve having clearly defined stages and decision points for realising innovation projects (Heras-Saizarbitoria et al., 2016). Such processes are critical factors for increasing a firm's competitive advantage due to their strong impact on performance by reducing costs (Adomako et al., 2021), improving quality (Martinez-Ros & Kunapatarawong, 2019) and enhancing production flexibility (Zahoor & Lew, 2021).

Regarding the specificities of SMEs, a closer link usually emerges between innovation capabilities and staff skills compared to large companies, particularly for those who are part of the management/entrepreneurial team (Janahi et al., 2022; Taipale-Erävala et al., 2019). Managerial literature (Handrito et al., 2021; Ofori-Amanfo et al., 2022) also highlights that SMEs frequently lack the necessary abilities and structures to systematically carry out innovation processes, such as internal R&D unit (Faccin et al., 2020). Not surprisingly, innovation capabilities in SMEs often emerge randomly, without a systematic process through which to develop and strengthen the underlying competencies, resources and skills.

According to these assumptions, we suggest the following hypothesis:

H1. *Competencies positively affect EICs in SMEs.*

3.2 | Technological factors

Having specific skills is a basic, but not necessarily a sufficient, condition for systematically pursuing innovation. It is also necessary to possess appropriate *technological factors* pertaining to the uses, processes and operations involved with technical aspects (Akbar et al., 2022; Iranmanesh et al., 2023). Such factors refer to how new advances in technology and equipment can affect the way a business operates, delivers its services and reaches specific markets, thereby improving business efficiency, reducing costs and enabling the development of new products and services. They include elements such as an internal structure devoted to R&D, technology spill-overs from external sources, advanced tools and devices, information and communication technology (ICT) and digital technologies, intellectual property, cross-functional teams, innovation monitoring and management tools and renewable energy sources (Akbar et al., 2022; Faccin et al., 2020).

It is reasonable to assume that a link exists between the presence of technological factors and business parameters such as size, type of activity, sector, content of output know-how and the forward-looking approach of ownership (Handrito et al., 2021; Martinez-Ros & Kunapatarawong, 2019). Among SMEs, compared to larger counterparts, technological factors may more closely affect how a company sells its services or products and how it collects information on its customers, suppliers or competitors so that it can respond or adapt to changes more effectively. Moreover, these factors contribute to defining the organisational structure of SMEs, which is essential for boosting innovation development by allowing effective coordination of innovation processes (Demirel & Kesidou, 2019; Yang, 2017). Due to increasingly dynamic and rapidly changing markets, SMEs must design an organisational structure capable of promoting innovation (Lozano, 2023; Ofori-Amanfo et al., 2022).

Therefore, technological factors are preparatory investments that lead to eco-innovations, and provide the foundation on which the skills possessed can realise their potential (Iranmanesh et al., 2023; Ko & Liu, 2017). Although eco-innovations are not solely technological (they also encompass broad-spectrum knowledge), the possession of technological factors highlights the use of cutting-edge tools that support investments in eco-innovations as a way to enhance economic opportunities identified by the company and thus generate or maintain a competitive advantage. Additionally, possessing technological factors is essential for establishing partnerships and networking with other companies, providing a common virtuous base for exchanging know-how and communications (Melander, 2018; Scuotto et al., 2017).

For these reasons, we hypothesise that a higher presence of technological factors increases the likelihood of improving EICs:

H2. *Technological factors positively affect EICs in SMEs.*

3.3 | Networking

As previously mentioned, the scientific literature agrees that when a company is small in terms of turnover, the difficulty in procuring all the resources needed to carry out its development and innovation programmes increases (Martinez-Ros & Kunapatarawong, 2019; Singh et al., 2021). This challenge affects both material and intangible resources, as well as the skills needed to support eco-innovation processes, which typically require broad-spectrum, heterogeneous knowledge. Similarly, the likelihood of insufficient investment in technological factors is very high in SMEs. For example, only a limited number of SMEs have an internal function to support absorptive capabilities or have established relationships with serial investors.

To circumvent these limits, the innovation capabilities of SMEs are often developed through participation in trade fairs, by imitation, through relationships with suppliers, customers and competitors, and via connections with universities, research centres and other public bodies that aim to support the innovation capabilities of the SMEs. Scholars label this approach as *networking* capabilities. This involves the ability to identify and establish connections and spot opportunities, and to capitalise on them. Companies that are dynamic in this regard typically have a competitive advantage. Not surprisingly, recent policy measures focus not just on providing financial incentives but also on fostering relationships with public and private research bodies or investors.

Network arrangements are increasingly seen as a strategic lever for economic development, especially at the regional level where public and private bodies, universities and research centres can promote the development of small businesses by providing a wide range of tools (Ismail et al., 2022; Janahi et al., 2022). Beyond these benefits, networking with other companies offers at least two additional advantages: the first is related to the agglomeration of companies (economies of scale, scope and complexity), and the second pertains to industrial relationships, such as the reduction of transaction costs (Adomako et al., 2021).

In summary, the ability of SMEs to participate in these innovation networks is a central component of business innovation for at least five reasons: (i) sharing the knowledge needed for innovation, (ii) more easily matching the financial needs to implement and test innovation, (iii) increasing the efficiency of research processes, (iv) sharing risks and uncertainties and (v) exploiting the specialised competencies of SMEs (Faccin et al., 2019; Scuotto et al., 2017).

As such, the ability of SMEs to enter and benefit from network relationships can be considered a prerequisite for eco-innovation, leading us to test the following hypothesis:

H3. *Networking positively affects EICs in SMEs.*

4 | METHODOLOGY

To assess whether and how *competencies*, *technological factors* and *networking* impact the innovation capability of SMEs, empirical research was carried out by developing a research model that measures and analyses the elements affecting EICs in SMEs. The causal hypotheses were tested through the partial least squares structural equations modelling (PLS-SEM) and by using the statistical software SmartPLS 4.0 (Ringle et al., 2005).

Generally, researchers have two methods to perform SEM analysis, namely covariance-based SEM or PLS-SEM. The main reason for using the latter technique in this study is that the data distribution assumptions are less stringent than the assumptions behind covariance-based SEM (Anderson & Gerbing, 1988).

4.1 | Research design

To achieve the aim of the study, we conducted a survey on a randomly selected sample of Italian innovative SMEs. Figure 1 illustrates the structural equation model, showcasing the underlying theory and its constructs, which are variables not directly measured (latent variables), depicted as ovals in structural equation models.

PLS, designed with a prediction-oriented approach through structural equation modelling (SEM), allows for the simultaneous estimation and testing of complex theories with empirical data. It is particularly suitable for exploratory research due to its statistical properties, which enable analysis with a limited number of observations and without assuming data distribution (Hair et al., 2012). In essence,

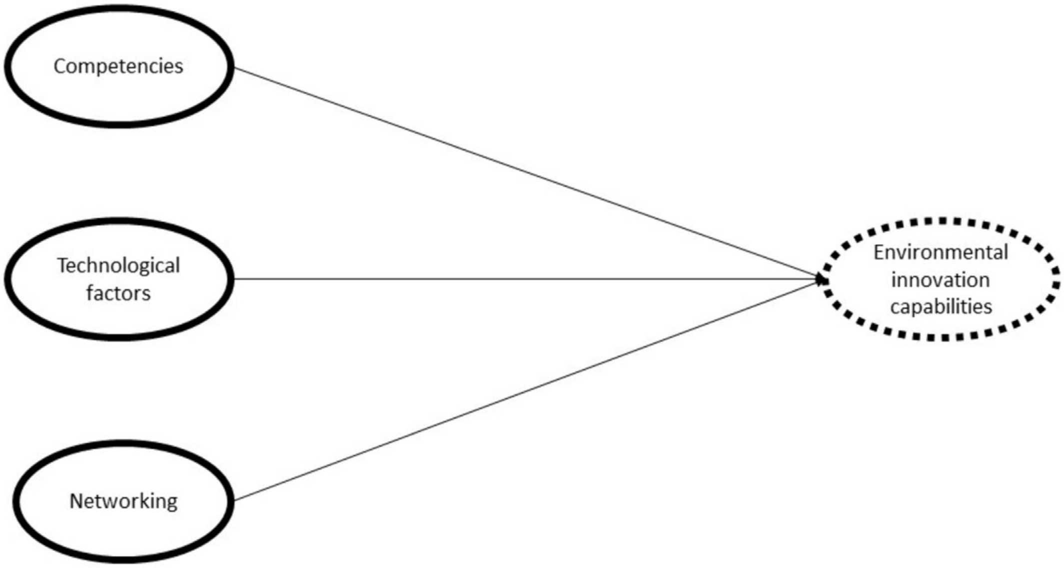

FIGURE 1 Model to be estimated.

PLS-SEM is advantageous for research that is 'simultaneously data-rich and theory-primitive' (Wold, 1985: 589).

4.2 | Sample selection

To achieve the objective of this study, we surveyed a population of young SMEs enrolled in a special register of the Italian Ministry of Economic Development called 'innovative SMEs', that is SMEs devoted to systematically pursuing innovative processes. Innovative SMEs are seen as vital for enhancing the country's competitive capacity (Castellano et al., 2022; Taipale-Erävala et al., 2019; Yang, 2017).

To be included in the register, the SME has to meet specific criteria such as investment in knowledge and R&D, ownership of patents and the education level of the entrepreneurial team. Once admitted, the SME is privy to certain benefits, such as credit loans, fiscal benefits, networking with eternal institutions and the possibility to raise capital through equity crowdfunding.

Aiming to identify the three antecedents of EICs previously discussed, the questionnaire (see the appendix) was validated by five experts (academics, practitioners and managers) and initially tested on five randomly selected innovative SMEs. Based on the feedback received from the pilot test, the questionnaire was improved to increase its clarity and consistency.

The sample units were chosen using probabilistic sampling, whereby an exhaustive population list was required. Created in 2015, the register currently includes around 2500 SMEs. To define a sample as homogeneous as possible and to minimise the limitations of previous investigations reported in Section 1, we decided to focus solely on Lazio, an Italian region of 15,000 km^2 characterised by a medium-high business climate. Companies without traceable websites, e-mail addresses or telephone numbers ($n = 43$) were removed. Stratified sampling was used due to the industrial heterogeneity of SME distribution, stratifying these by industry. It is worth underlining that we decided to not consider SMEs operating in the commercial or hospitality industry, due to their intrinsic high heterogeneity. A random sample was then selected from each stratum based on the industrial representation in the population. The sample size was set at 281 units, representing about 80% of the innovative SMEs based in the Lazio region.

All selected SMEs were invited to complete an online questionnaire with closed questions on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree). An e-mail was sent to the sample units explaining the survey's goals and the concept of EICs, with a direct link to the questionnaire, requesting completion by the most informed person. After multiple follow-up requests, about half of the SMEs responded to the survey, resulting in a final sample of 140 SMEs. The questionnaire was filled out by the directors/managers of the research and development units (67% of cases), top managers (18%), CEOs (9%) and CFOs (6%).

Table 1 reports the main characteristics of the SMEs included in the sample.

4.3 | Data analysis method

As mentioned prior, this research makes use of PLS-SEM to analyse the theoretical model presented in the previous paragraphs. SEM has several advantages over more traditional techniques, such as principal components analysis, factor analysis, discriminant analysis and multiple regression.

First, SEM allows researchers to model relationships among multiple predictor and criterion variables (Chin, 1998). Second, SEM allows the researcher to analyse multiple dependence relationships simultaneously. In this context, a variable hypothesised as dependent in one relationship can serve as an independent variable in another. In

TABLE 1 The main characteristics of the SMEs included in the sample.

	Frequency (*n*)	%
Sector		
Trade	7	5.00
Manufacturing	26	18.57
Service	107	76.43
Total	140	100.00
Turnover (€ 000)		
0–1000	112	80.00
1001–5000	23	16.43
>5001	5	3.57
Total	140	100.00
Employees		
0–9	91	65.00
10–49	45	32.14
50–250	4	2.86
Total	140	100.00
Capital		
<100,000	114	81.43
100,001–1,000,000	21	15.00
>1,000,001	5	3.57
Total	140	100.00

Abbreviation: SMEs, small and medium-sized enterprises.

contrast, traditional multivariate regression only permits the analysis of one relationship at a time (Hair et al., 2006). Third, SEM provides the ability to measure latent (unobservable) variables. Additionally, with SEM, a single comprehensive analysis can be conducted based on two models: (i) measurement model, which describes how each latent variable can be derived from explicit variables (indicators), and (ii) structural model, which hypothesises causal relationships based on a set of dependent and independent theoretical structures. By applying this technique, researchers can assess whether indicators fail to accurately represent latent variables, as well as their ability to construct models of relationships among multiple variables and identify connections between prior knowledge and empirical hypotheses. Finally, SEM allows researchers to assess the measurement models and structural models simultaneously.

Additionally, this study focuses on eco-innovation processes characterised by the existence of endogeneity (e.g. Gilson, 2010; Hille & Möbius, 2019); in deciding to tackle this issue, it is expected that the reliability and validity of our results are improved. In fact, as Ullah et al. (2018) explain, 'Endogeneity in regression models refers to the condition in which an explanatory variable (e.g. research and development expenditures) correlates with the error term, or if two error terms correlate when dealing with structural equation modelling' (p.1). Endogeneity bias can lead to inconsistent estimations and incorrect inferences about the effect of different antecedents on innovation processes (Nguyen et al., 2008). In that sense, endogeneity poses a significant challenge in managerial studies, and researchers must carefully consider and address this issue to ensure the reliability and validity of their research findings (Zaefarian et al., 2017). Despite this, many scholars in management disciplines are not fully aware of endogeneity and its sources, or of any effective solutions (e.g. Antonakis et al., 2014; Zaefarian et al., 2017). As such, addressing endogeneity is crucial for theory testing and development in management research, as it ensures the accurate estimation of relationships and provides meaningful guidance to practitioners (e.g. Qian et al., 2024).

One commonly used approach to address endogeneity (or simultaneity) is the instrumental variables method, which is applicable to various sources of endogeneity (e.g. Nguyen & Adomako, 2021). However, finding suitable instruments that meet the necessary criteria of correlation and exogeneity can be challenging.

Amongst the instrumental variable-free approaches, the Gaussian copula method is particularly popular. The Gaussian copula approach is an instrument-free method that has been increasingly used in management research to address endogeneity when instrumental variables are not readily available or suitable (e.g. Eckert & Hohberger, 2023). For this reason, to eliminate the presence of simultaneity in the model, it was preferred to introduce the Gaussian copula in its specification.

5 | RESULTS

The PLS path model requires the analysis and interpretation of both the measurement (outer model) and the structural (or inner) models. Specifically, the model assessment follows a three-stage process:

1. Assessment of the measurement model, evaluating the internal consistency reliability and convergent validity by Cronbach's alpha (α), average variance extracted (AVE), factor loading analysis and discriminant validity;
2. Assessment of the structural model by considering the R^2 and adjusted R^2;
3. Validation of the model through the bootstrapping technique.

The measurement model test refers to how the constructs have been operationalised and, thus, measured by using manifest variables. The objective of the analysis is to assess the reliability (Cronbach's α and AVE) and validity of measures (discriminant validity). In short, reliability means that an instrument will consistently measure something; validity means that it will measure what it is intended to measure (Spector, 1992).

The measurement reliability of the constructs was evaluated using Cronbach's α and AVE. In the literature, Cronbach's α is one of the most common indexes used to evaluate internal consistency. Cronbach's α is a measure of the proportion of variance among a group of indicators that is attributable to a common factor (Cronbach, 1951). Cronbach's α provides an index score that ranges from 0 to 1. The α for a good scale should be greater than .7, meaning that 70% of the variance among the indicators is common. AVE measures the amount of variance captured by the indicators in relation to the amount of variance due to measurement error (Fornell & Larcker, 1981). AVE should be greater than 0.5 (Chin, 1998).

Table 2 shows the Cronbach's α and AVE for all the considered constructs. We applied the following cut-off values during the data analysis: (i) AVE higher than 0.5 (Hair et al., 2012) and (ii) Cronbach's α higher than .7 (Hair et al., 2012).

The internal consistency reliability coefficients of the five scales/subscales as assessed with Cronbach α range between .801 and .898. Overall, these coefficients can be considered satisfactory.

The convergent validity was also assessed by analysing whether each item had a statistically significant factor loading on its specified factor (Netemeyer et al., 1990). Specifically, we follow a multi-step, iterative estimation procedure so as to obtain the 'best model'. It is commonly assumed that loadings greater than 0.6 are acceptable, while values slightly below 0.6 might be acceptable for newly developed measures. Indicators with loadings smaller than 0.6 have to be removed. We begin by estimating a first model in which all the 34 indicators are partitioned into the four mentioned latent variables. We observe that some of the indicators present loading smaller than the threshold level; we therefore remove three of these indicators (Q2, Q3 and Q7) and perform a new model estimation. We repeat these steps until all the loadings are greater than 0.6. The iterative procedure suggests the removal of Q12, Q18, Q22, Q27 and Q29 (Roldán & Leal, 2003). At the end of the iterative procedure, we observe that all the items considered in the measurement model show loadings greater than 0.6 (Table 2). Therefore, items show a sufficiently high relationship with their own latent variables.

Regarding the model validity, it is important to verify also the discriminant validity. Discriminant validity is the extent to which the measures of different concepts are distinct (Bryant, 2000). Discriminant validity was assessed using the method prescribed by Gefen and Straub (2005), specifically AVE analysis. AVE analysis is performed by comparing the square root of the AVE with the correlation between the construct and every other construct. The square root of the AVE should be much larger than the correlations with the other constructs (Fornell & Larcker, 1981). Table 3 shows the correlations between the constructs and the square root of the AVE.

TABLE 2 Factor loadings, reliability and validity.

Manifest and latent variables	Factor loadings	Standard error	*p*-value	Cronbach's α	AVE
Q1 <- environmental innovation capabilities	0.908	0.026	.000	0.852	0.507
Q4 <- environmental innovation capabilities	0.942	0.010	.000		
Q5 <- environmental innovation capabilities	0.602	0.061	.000		
Q6 <- environmental innovation capabilities	0.698	0.080	.000		
Q8 < - environmental innovation capabilities	0.650	0.093	.000		
Q9 <- environmental innovation capabilities	0.651	0.093	.000		
Q10 <- environmental innovation capabilities	0.945	0.008	.000		
Q11 <- environmental innovation capabilities	0.679	0.070	.000		
Q13 <- technological factors	0.939	0.018	.000	0.801	0.611
Q14 <- technological factors	0.954	0.017	.000		
Q15 <- technological factors	0.638	0.103	.000		
Q16 <- technological factors	0.954	0.017	.000		
Q17 <- technological factors	0.634	0.115	.004		
Q19 <- competencies	0.887	0.029	.000	0.898	0.594
Q20 <- competencies	0.896	0.025	.000		
Q21 <- competencies	0.891	0.022	.000		
Q23 <- competencies	0.690	0.070	.000		
Q24 <- competencies	0.609	0.078	.000		
Q25 <- competencies	0.596	0.080	.000		
Q26 <- competencies	0.687	0.067	.000		
Q28 <- competencies	0.891	0.027	.000		
Q30 <- networking	0.744	0.063	.000	0.842	0.543
Q31 <- networking	0.657	0.124	.000		
Q32 <- networking	0.810	0.091	.000		
Q33 <- networking	0.653	0.124	.000		
Q34 <- networking	0.804	0.091	.000		

TABLE 3 Discriminant validity results.

	Eco-innovation capabilities	Competencies	Networking	Technological factors
Eco-innovation capabilities	0.712	-	-	-
Competencies	0.702	0.771	-	-
Networking	0.692	0.729	0.736	-
Technological factors	0.709	0.629	0.719	0.781

TABLE 4 Assessment of the structural model.

Constructs	R^2	R^2 adjusted
Eco-innovation capabilities	0.898	0.893

In each case, the square root of the AVE is larger than the correlations of the construct with all the other constructs. Therefore, the data passed the test of discriminant validity.

Once the reliability and validity of the measurement model have been verified, we can proceed to the evaluation of the structural model and, thus, to test our hypotheses. To evaluate the quality of the structural model, we examine the determination coefficients (R^2) of the endogenous latent variables. For each regression in the structural model, we have an R^2 that is interpreted in a similar manner as any multiple regression analysis: it indicates the amount of variance in the endogenous latent variables that is explained by its independent variables (Table 4).

As shown in Table 5, the inner model appears to be correct. According to the literature (Cohen, 1992), the computed R^2 coefficient can be considered large for the EIC variable.

The model presented in Figure 1 was tested using PLS-SEM. Table 5 shows the estimated path coefficients, the *T*-statistics and the *p*-values. Analysing the structural model, we observe that the impact of technological factors and competencies on EICs is positive and statistically significant. On the contrary, the path coefficient among networking on EICs is negative and not statistically significant (*p*-value = .031).

It is worth underlining that both technological factors and competencies are critical variables in supporting EICs of SMEs, although the impact of competencies is higher than that of technological factors (0.930 and 0.342, respectively). Hence, H1 and H2 are verified. On the contrary, we must reject H3 (Figure 2).

Furthermore, the application of the Gaussian copula approach in our study allowed us to detect the presence of endogeneity in the relationships between our three key variables (competencies, technological factors and networking) and EICs. This is an essential step as ignoring endogeneity could lead to incorrect inferences about the effects of these antecedents on EICs. Specifically, by using the Gaussian copula, we were able to correct for the endogeneity bias. This correction ensures that the estimates of the impact of these variables on EICs are more accurate and reliable. Consequently, the relationships we identified are more likely to reflect true causal effects rather than spurious correlations driven by omitted variable bias or measurement error.

In summary, the inclusion of the Gaussian copula terms in our SEM improved the overall fit of the model. Better model fit indicates that the model more accurately represents the underlying data structure. Our findings regarding the significant antecedents of EICs remained robust even after accounting for endogeneity. This robustness adds confidence to our results, suggesting that the identified relationships are not artefacts of statistical bias but reflect genuine underlying processes.

6 | DISCUSSION

The analysis carried out shows that *competencies* and *technological factors* are two very influential antecedents of EICs for SMEs. Regarding competencies (H1), this result confirms that the innovation path must be supported by specific abilities and skills of a company's employees and the entire organisation. These skills help SMEs to identify and discover economic opportunities linked to the important transformations involving production systems with respect to the environmental and social dimensions linked to sustainable development. Innovation capacity and flexibility in dealing with addressing problems inherent in the implementation of innovation projects can also be considered crucial for SMEs, representing a precondition for the implementation of EICs.

Referring to the specificities of the innovative SMEs investigated, which are inherently open to constant change in their business model, it is believed that the factors mentioned have an even more important role. This happens because innovative processes take place without interruptions, meaning continuous structured processes of adapting skills, abilities and knowledge. Therefore, only proactive SMEs that focus their efforts primarily on knowledge can hope to remain on the list of innovative SMEs. On the other hand, the requirements for being enrolled in this special register require that SMEs give an account of their orientation towards innovation, starting with the availability of highly qualified personnel, the possession of patents, a minimum share of resources invested in research and development and so on.

Concerning innovative SMEs, the aim of the special register is to support the growth and development of these SMEs by providing mainly non-financial instruments. This is because, as already explained and outlined in the entrepreneurial literature, innovative companies are those that are capable of modifying the productive specialisation of the area in which they operate. Public administrations, therefore, intend to invest in these SMEs mainly to accelerate the diffusion of

TABLE 5 Structural model—path coefficients, standard errors and *p*-values.

Latent variables	Path coefficients	*T*-statistics	*p*-values	Decision
Technological factors → EICs	0.342	1.901	.057	H1 accepted
Competencies → EICs	0.930	4.326	.000	H2 accepted
Networking → EICs	−0.242	1.450	.147	H3 rejected

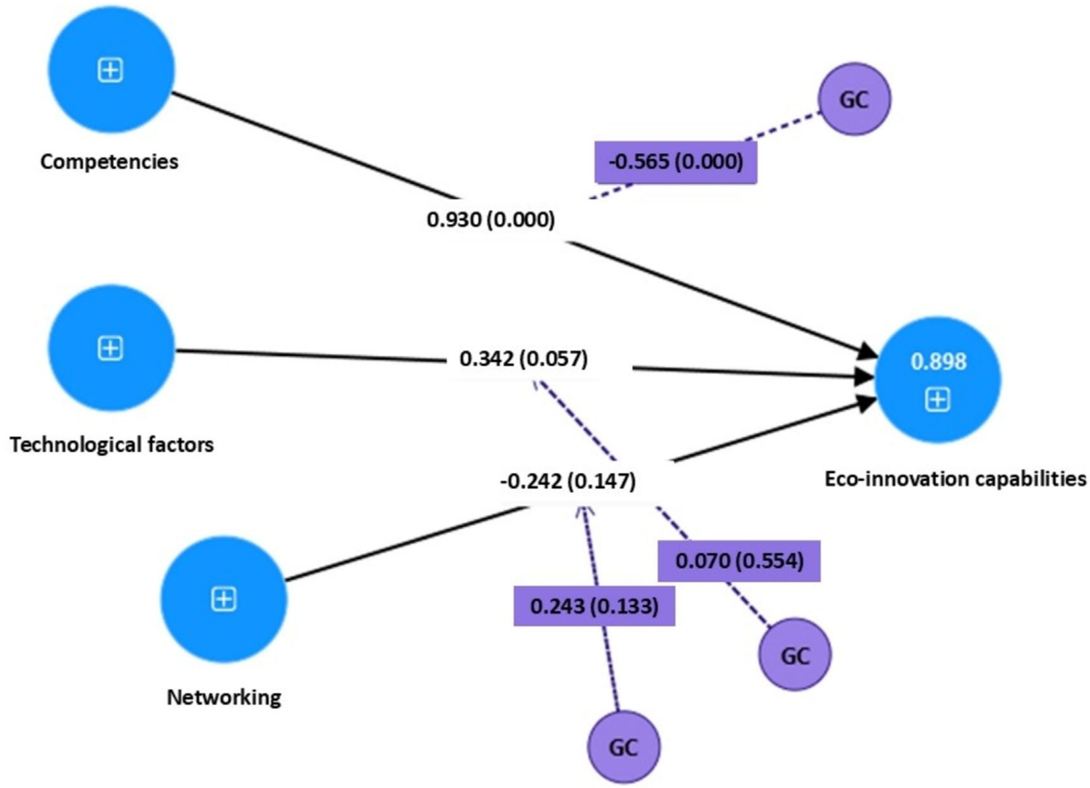

FIGURE 2 The estimated model (**p*-value < .05). *Note*: Path coefficients are on the arrow, while *p*-values are in parenthesis.

know-how and support cross-fertilisation of the territory, rather than to encourage an increase in employment with labour-intensive activities. It is important to bear in mind that these innovative SMEs, despite tending to be more fragile as they operate in borderline activities, have a high potential for expansion and development.

The starting point of this process, whereby the adoption of innovations is stimulated, lies in a change of mentality that pushes entrepreneurs and owners to consider innovation not as a challenge with an uncertain outcome, but as a behavioural routine of management. In other words, SMEs that invest in eco-innovations are in fact aware that they cannot be certain about the benefits deriving from these advanced processes, although they are sure that without sufficient innovations, their business will end up being displaced or crowded out.

Possession of technological factors (H2) responds to the same rationale. The presence of such factors is an unequivocal signal of the SME's willingness to pursue a path of innovation. These technological factors presuppose the basic investment of economic organisations into the ICT structures and equipment needed to successfully capitalise on those innovations that support the presence of the aforementioned specialised skills.

Technological factors are a constitutive element of a company's organisational structure. Without the right organisational structure, SMEs, more so than large companies, find it difficult to achieve high levels of innovative performance (Taipale-Erävala et al., 2019; Yang, 2017). Similarly, it is plausible that the provision of technological factors is even more important for innovative SMEs than for traditional ones. In many cases, investments in technological factors supporting EICs allow for adaptation to societal pressure and related environmental awareness, or to regulations/incentives proposed by public administrations.

The rejection of H3 regarding the influence of *networking* on EICs can be considered unexpected. Most of the scientific contributions published in recent years agree on the importance of networking with other companies or public/private institutions (e.g. Carfora et al., 2021; Scuotto et al., 2017). Networking is even more important for SMEs due to their lack of tangible and intangible resources necessary to feed innovation processes. Networking abilities are thus considered a pivotal strategic lever of SMEs' competitiveness (Melander, 2018; Passaro et al., 2023).

However, although researchers consider the presence of deep-rooted and developed networking in a positive light, some investigations have highlighted the presence of possible critical issues that tend to penalise weaker networking companies. This is due to possible cognitive distance among SMEs' employees, the direct competition between companies, the increase in transition costs, problems with coordination, uncertainty about the contribution of partners or the inadvertent spill-over of critical knowledge leaks. All of this requires SMEs to implement costly appropriability strategies; a process that is more difficult for small or micro companies when managing the many linkages with larger, more established partners that often have more contractual power (e.g. Castellano et al., 2022; Ismail et al., 2022).

Focusing on the investigated SMEs, this study posits another explanation. As previously mentioned, networking allows SMEs to obtain benefits focused on the provision of real services and support tools able to support the development of eco-innovations. Among these exist linkages with universities, research centres and other public and private entities. We can therefore assert that the SMEs interviewed do not feel the need to network to generate their own EICs because this crucial gap has already been filled.

The previous observation also seems to contradict another commonplace notion that the main weakness of SMEs wishing to innovate is the lack of financial resources. To avoid speculative behaviours aimed exclusively at obtaining financial resources, SMEs enrolled in the special register do not receive direct financial contributions; on the contrary, being enrolled helps SMEs to develop relationships with specialised actors able to provide financial support, such as serial investors, business angels or venture capitalists. Furthermore, other laws—both at the national and EU levels—usually offer financial advantages to companies that invest in those innovations that respect the rules of sustainable development or the acceleration of energy transition.

Furthermore, innovative SMEs seem to show a different level of managerial maturity compared to other types of SMEs. This means behaviours and expectations that are more consistent with those emerging from recent scientific investigations regarding the tools used to promote the competitiveness of SMEs based on their propensity for innovation (Hervás-Oliver et al., 2021; Passaro et al., 2023; Xavier et al., 2017).

7 | CONCLUSION

7.1 | Contribution

Business and managerial scholars agree that the adoption of wide-ranging eco-innovations consistent with the principles of sustainable development is crucial for achieving high environmental and economic performance in companies. However, there is less consensus regarding the elements that drive a company's willingness to invest in eco-innovations. This uncertainty is even greater for SMEs, which have diverse operational and management characteristics compared to large companies, and even among themselves. This study investigates the factors that support the propensity of SMEs to invest in EICs.

Unlike many other studies on this topic, this paper does not aim to identify static elements whose presence is associated with the ability to invest in eco-innovations (e.g. monetary resources). Instead, it evaluates three elements that dynamically contribute to the emergence of EICs within SMEs. To avoid the vagueness that characterises many previous surveys, which consider large aggregates of SMEs with heterogeneous structural variables, behaviours, experiences and external influences, we examine a highly homogeneous sample. This sample consists of SMEs that have deliberately chosen to pursue innovation.

Our outcomes show that competencies and technological factors are highly significant, while networking is not significant. This finding seems surprising, but it can be explained by the novelty of the SMEs considered. These SMEs were selected from a specific register devoted to innovative SMEs, where registration does not involve financial incentives (often subject to speculation in the past), but rather real services and support facilities. These support tools include networking with specialised partners.

Furthermore, the adoption of PLS-SEM allowed us to model relationships among multiple predictor and criterion variables and to analyse multiple dependence relationships simultaneously. Finally, the application of the Gaussian copula approach in our study has provided a more accurate understanding of the determinants of EICs among SMEs. By addressing endogeneity, we have ensured that our results are both reliable and actionable, offering valuable insights for fostering innovation in SMEs.

7.2 | Theoretical implications

This research contributes to the scientific debate regarding the main factors influencing EIC in innovative SMEs. The proposed methodology allows us to identify and correct for endogeneity in the relationships between key variables such as competencies, technological factors and networking and EIC. Correction helps prevent improper inferences and ensure that our estimates of factors influencing EICs are accurate and reliable, reflecting real causal effects rather than spurious correlations.

The adopted PLS-SEM model fits better overall when the Gaussian copula variables are added. A better model fit means that the underlying data structure is more faithfully represented. Even after accounting for endogeneity, our conclusions about the important antecedents of EICs held true. This robustness strengthens our findings by indicating that the associations found are real underlying processes rather than random effects of statistical bias.

The sample of SMEs examined is characterised by a high degree of homogeneity in terms of structural variables, orientation towards innovation, ownership (team of young entrepreneurs with high levels of education), territorial context and public support received. This homogeneity allowed us to obtain more reliable results that could be useful to other categories of SMEs and policymakers. We also believe that having observed a sample composed only of innovative SMEs is to be considered of particular interest. Our choice is justified by the contribution of these SMEs to territorial development and the transition towards more advanced and eco-sustainable industrial models.

7.3 | Practical implications

Based on the results of this study, several important implications emerge, particularly for policymakers. The findings can help guide the development of policies and measures that encourage organisations with high potential to pursue eco-innovation while ensuring societal well-being through the dissemination of knowledge and best practices in environmental management. The situation is more complex for SMEs, as they often face greater challenges in acquiring the tangible and intangible resources necessary to adopt and develop eco-innovative processes.

From a policy perspective, this study provides valuable insights into the key challenges surrounding the management, development and adoption of eco-innovations. Specifically, the results could inform policymakers in designing comprehensive initiatives that stimulate SMEs to adopt eco-friendly behaviours, actions and strategies to reduce their environmental impact. In line with our research, various types of policy measures could be developed, such as (i) financial support, tax incentives and consulting services to encourage investment in eco-innovations; (ii) education and training programmes to equip firms with the skills, knowledge and competencies needed for eco-innovation; and (iii) soft measures (e.g. public campaigns, workshops, fairs) to enhance SMEs' sensitivity and awareness to environmental issues.

It is important to emphasise that developing tailored policies for SMEs is particularly critical to support their adoption of eco-innovation processes. On the one hand, given SMEs' limited financial resources, substantial monetary incentives are essential to stimulate investment in environmentally friendly innovations, thereby enhancing said SMEs' competitiveness and ability to address pressing environmental challenges. On the other hand, soft measures are also vital for SMEs, as they can inspire young, highly educated entrepreneurs to engage in eco-innovation. Such measures, which seem more effective and less costly for public funds, can activate the latent expertise already present in public institutions, driving innovation more effectively.

In summary, policymakers can leverage these findings to design measures that address the challenges of eco-innovation adoption and support the transition towards a more sustainable economy.

In addition to policy implications, our results offer valuable insights for managers. The study underscores the importance of strengthening competencies and technological capabilities to drive eco-innovation. In particular, appropriate organisational structures allow SMEs to seize opportunities, create customer value and sustain eco-friendly growth. To achieve this, SMEs must gain a clear understanding of how various aspects of their business—resources, processes, structures and strategies—affect their performance.

The study highlights the need for SMEs to enhance their resources, skills and core competencies in areas such as innovation orientation, environmental management and project flexibility. Moreover, SMEs should be supported in adopting and managing key processes (e.g. idea generation, project screening, implementation, commercialisation) that are crucial for the success of eco-innovation initiatives.

7.4 | Limits and future research

As with all research, this study has certain limitations. One major limitation is the sample of SMEs, which is confined to a restricted geographical area. While this homogeneity is a strength of the study, extending the research to other Italian regions and comparing results is necessary to validate the findings. Future research could also compare the EICs of SMEs in different European countries or globally. Additionally, examining different types of non-innovative SMEs could reveal potential similarities and differences.

To ensure the effectiveness of the outcomes, this study only considered three determinants. Future research could explore additional factors to provide more comprehensive insights into EICs among SMEs. Enriching the questionnaire to observe SMEs' behaviour regarding innovation management in greater detail could also be beneficial. Other methodological approaches, such as multiple case studies, fuzzy qualitative comparative analysis, cluster analysis and hierarchical regression analysis, could be employed to study specific aspects and roles of different variables more deeply.

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ORCID

Giovanna Ferraro https://orcid.org/0000-0003-4053-7649
Ivana Quinto https://orcid.org/0000-0003-3606-9029
Antonio Thomas https://orcid.org/0000-0003-0029-8938

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APPENDIX A: The questionnaire

Latent variables	Considered items
Environmental innovation capabilities (Q1–Q11)	**Q1:** The organisation is often actively engaged in eco-innovation activities.
	Q2: The organisation is continually moving towards implementing new cleaner processes.
	Q3: The organisation often emphasises the development of new eco-products through new technologies.
	Q4: The organisation is continuously oriented to modify existing products to make them more environmentally friendly.
	Q5: The organisation shows a high commitment to generating green approaches.
	Q6: The organisation seeks creative solutions to environmental problems.
	Q7: The environmental sustainability is a very sensitive issue in the organisation.
	Q8: The organisation is oriented towards identifying new organisational approaches to achieve the environmental goals.
	Q9: The organisation has a documented plan or rules for eco-innovation and ecological management.
	Q10: The organisation integrates existing green knowledge with new green knowledge.
	Q11: The organisation places emphasis on eco-innovation developments.
Competencies (Q19–Q28)	**Q19:** The organisation encourages employees to master and use new environmental knowledge in its operations.
	Q20: The organisation encourages the improvement of staff innovation skills.
	Q21: The eco-innovations that the organisation intends to adopt are in line with current technological skills?
	Q22: The eco-innovations that the organisation intends to adopt are in line with current organisational skills?
	Q23: The eco-innovations that the organisation intends to adopt are in line with current managerial skills?
	Q24: Employees propose environmental sustainability actions.
	Q25: There are professional figures (e.g. energy managers) who are dedicated to environmental sustainability issues.
	Q26: The organisation plans to hire professionals dedicated to environmental sustainability issues.
	Q27: The organisation encourages staff to work towards energy saving and emission reduction.
	Q28: The organisation adopts effective project management systems to implement eco-innovations.
Technological factors (Q12–Q18)	**Q12**: The organisation has an internal R&D structure.
	Q13: The organisation develops internal R&D activities oriented towards the development of eco-innovations.
	Q14: The organisation considers environmental auditing as a management standard.
	Q15: The organisation adopts cross-functional teams to support eco-innovation developments.
	Q16: The organisation uses strategic tools to support eco-innovations.
	Q17: The organisation adopts a system of rewards and recognition to support eco-innovation processes.
	Q18: The organisation often invests a high percentage of R&D funds into eco-innovation.
Networking (Q29–Q34)	**Q29**: The organisation sees the relationship with customers as important for accessing eco-innovations.
	Q30: The organisation sees the relationship with suppliers as important for accessing eco-innovations.
	Q31: The organisation sees the relationship with other companies as important for accessing eco-innovations.
	Q32: The organisation sees the relationship with public entities as important for accessing eco-innovations.
	Q33: The organisation sees the relationship with universities/research centres as important for accessing eco-innovations.
	Q34: The organisation sees the participation in workshops/exhibitions as important for accessing eco-innovations.