

**OPEN ECO-INNOVATION:  
AT THE CROSSROAD OF SUSTAINABILITY, INNOVATION, AND  
BUSINESS PERFORMANCE.**

**Doctoral Thesis**

**Ph.D. programme in Business and Territorial Competitiveness,  
Innovation and Sustainability**

**Deusto Business School**

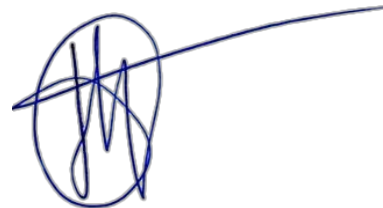
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## LIST OF ABBREVIATIONS

Abbreviation	Term
OEI	Open Eco-innovation
OSI	Open Sustainable Innovation
EI	Eco-innovation(s)
OI	Open Innovation

## LIST OF PUBLICATIONS

Chistov, V., Aramburu, N., & Carrillo-Hermosilla, J. (2021). Open eco-innovation: A bibliometric review of emerging research. *Journal of Cleaner Production*, 311, 127627. <https://doi.org/10.1016/j.jclepro.2021.127627>

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## **ABSTRACT**

In today's rapidly changing world, organizations face increasing pressure from society to adopt more sustainable practices, reduce their environmental impact, and promote social justice. Simultaneously, they are also faced with the challenges of technological advancements, societal shifts, and intensified competition. Therefore, finding the right balance between sustainability and business performance becomes a crucial objective for these organizations. Recent developments in sustainability literature suggest that embracing sustainability orientation can provide firms with a competitive advantage, ensuring their survival and fostering growth in the long run. Furthermore, innovation is seen as a potential bridge that can reconcile sustainability and business objectives. However, empirical studies highlight the inherent difficulties in aligning sustainability, innovation, and business performance. Many organizations lack the necessary resources, skills, and knowledge to effectively integrate these aspects. This dissertation contributes new empirical evidence that demonstrates the positive relationship between sustainability orientation and business performance (i.e., growth) in the long term. Moreover, it sheds light on the complex nature of combining sustainability and innovation, which does not always bring the expected outcomes. It also shows that this challenge can be addressed through an Open Eco-innovation strategy, highlighting the role of collaboration with external partners and leveraging knowledge from stakeholders in the interplay between environmental sustainability and innovation (i.e., eco-innovation), particularly when pursuing more radical environmental objectives. These results aim to encourage organizations to embrace such open approaches and become a driving force in the sustainability transition of our society.

**KEYWORDS:** eco-innovation, open eco-innovation, sustainability orientation, business performance

## **1. RESEARCH MOTIVATION**

### **1.1 Research Justification**

The world today is currently facing an array of interconnected and unprecedented challenges spanning social, economic, and environmental domains. These challenges often referred to as the Grand Challenges of our society (Bogers et al., 2020; George et al., 2016; Villar et al., 2019), encompass issues such as economic inequality, social justice, climate change, biodiversity loss, and depletion of natural resource (Souto, 2022). The urgency and magnitude of these challenges demand a departure from incremental and isolated solutions (Kennedy et al., 2017; Steffen et al., 2018) and a move toward more radical transformation. Within academic literature, this shift is referred to as “sustainability transition” (de Gooyert et al., 2016; Hörisch, 2015; Köhler et al., 2019; Markard et al., 2020). It entails the changes in the ways we operate as a society, distribute wealth and engage in the production, delivery, and consumption of goods and services, as well as the proper management of waste (Westman et al., 2022; Xin et al., 2022). Its main objective is to establish more sustainable and resilient socio-technological systems that effectively meet present needs while safeguarding the ability of future generations to meet their own needs (Brundtland, 1987).

The sustainability transition entails a fundamental shift in the paradigm of how firms approach sustainability (Porter & Kramer, 2011). Historically, many organizations were reluctant to introduce sustainability objectives, following a more “traditionalist” view (Palmer et al., 1995; Simpson & Bradford, 1996; Walley & Whitehead, 1994; Xepapadeas & De Zeeuw, 1999) that assumed that sustainability orientation is incompatible with business objectives and would ultimately hurt their performance (Linder et al., 2014; Palmer et al., 1995; Stevens et al., 2015; Walley & Whitehead, 1994). However, the rise of awareness about the Grand Challenges (Ben Amara & Chen, 2020b; Melander & Pazirandeh, 2019), the focus from the international community (Urpelainen, 2012), changes in environmental regulations (Beise & Rennings, 2005; Dechezleprêtre & Sato, 2014), demand from consumers for more sustainable alternatives (demand-pull) (Amores-Salvadó et al., 2014; De Castro et al., 2006; del Río, Peñasco, et al., 2015), and the rapid development of new disruptive technologies (technology-push) are changing the fundamental dynamics in the market (Allal-Chérif et al., 2023; Xin et al., 2022). These factors are contributing to an evolving understanding of the

relationship between sustainability and business performance, prompting firms to reconsider their approach to sustainability (Aragón-Correa & Rubio-López, 2007; Ben Amara & Chen, 2020a). As a result, many organizations shift towards a so-called “revisionist” perspective and increasingly explore innovative ways to integrate sustainability objectives into their core business processes and strategies, fostering a more harmonious and synergetic relationship between the two domains and unlocking new opportunities for growth and competitive advantage (Hahn et al., 2015; Porter & Kramer, 2011; Porter & Linde, 1995; Shrivastava, 1995).

In their seminal work, Porter & Kramer (2011) suggest that firms should take the lead in the sustainability transition of our society by adopting a new model of "shared value," which encourages organizations to simultaneously create economic value and societal value, achieving the triple-bottom-line of social, environmental, and economic goals (Belz & Binder, 2015; Camilleri et al., 2023). The authors argue that the incorporation of sustainability objectives into their organizational processes incentivizes firms to acquire valuable, rare, and inimitable resources and capabilities (Barney, 1991; Hart, 1997). Furthermore, severe government penalties for unsustainable practices compel firms to innovate, leading to operational efficiencies, higher-quality products, and enhanced value for customers (Claudy et al., 2016). With the rise of consumers' concerns about the sustainability of products and services they purchase, sustainability orientations can also differentiate firms from competitors (De Castro et al., 2006; Prothero et al., 2010). As a result, sustainability orientation within firms (i.e., the pursuit of social or environmental goals beyond commercial objectives) may become a sustainable competitive advantage (Albort-Morant et al., 2017; Bhuiyan et al., 2023; Carrillo-Hermosilla et al., 2009; Claudy et al., 2016) and positively affect their triple-bottom-line performance and growth in the long run (Shehzad et al., 2023).

One of the other most significant and extensively studied determinants of the business performance of organizations to date is innovation (Mousavi et al., 2018). With few notable exceptions, extensive empirical research supports the notion that innovation significantly enhances a firm's performance (Gunday et al., 2011; Han et al., 1998; Rajapathirana & Hui, 2018). Considering the potential positive impacts of both sustainability orientation and innovation on performance and growth, it is reasonable to expect that the integration of these two drivers may further amplify their cumulative positive influence on business performance. This assumption has spurred intensive research into the relationship between sustainability and

innovation, as well as related concepts such as sustainable innovation (Hellström, 2007; Inigo & Albareda, 2016; Velter et al., 2019), eco-innovation (Carrillo-Hermosilla et al., 2010; Kiefer, Carrillo-Hermosilla, et al., 2019; Kiefer et al., 2018), and social innovation (Alonso-Martínez et al., 2019; Segarra-Oña et al., 2017). Studies demonstrate that innovation in sustainability-oriented ventures enables them to differentiate themselves from competitors, improve cost structures, build positive reputations with consumers and stakeholders, and create a long-term competitive advantage (Allal-Chérif et al., 2023; Aragón-Correa & Sharma, 2003; Handy, 2022). Some authors suggest that a transition to a more sustainable world is inherently dependent on novel products, services, processes, and business models (de Gooyert et al., 2016; Köhler et al., 2019). Consequently, innovation is perceived as a powerful tool for reconciling sustainability with business performance, as well as a driver of the sustainability transition of our society (Afeltra et al., 2023).

Despite the fact that innovation in sustainability-oriented organizations offers significant potential for business performance, only a small proportion of businesses actively pursue sustainability objectives and invest in sustainability-oriented innovations (Chistov et al., 2023; Cohen & Winn, 2007). This can be attributed to the multiple challenges and liabilities related to sustainability (Marin et al., 2015). For instance, when firms embark on such endeavors, they often have to deal with significant obstacles such as scarce external financing, unhelpful regulations, uncertain market demand, unclear returns on investment, and the lack of proper knowledge and skills to develop new environmental solutions (del Río et al., 2010; del Río et al., 2015). They also tend to face the problem of double externality when involuntary knowledge spillovers reduce the motivation of firms to invest in particular types of sustainable innovations (i.e., eco-innovations) (Del Río, 2004; Kanda et al., 2018; Rennings, 2000) or even a triple externality problem when other organizations fail to benefit from the spillovers (adoption externalities) (Dybvig & Spatt, 1983). In addition, the degree of radicalness, complexity, and systemic nature that is typically connected with sustainable innovations tends to be higher than in other types of innovations, which further complicates the process of their adoption and implementation (Inigo et al., 2020; Mothe & Nguyen-Thi, 2016).

The recent literature suggests that many challenges that arise when sustainability-oriented firms employ innovation could be addressed through proper collaboration and supplementing internal R&D processes with resources from external partners (Acebo et al., 2021; Kiefer, Del Río González, et al., 2019; Stål et al., 2023). In fact, due to their novelty and

complex nature, sustainable innovations often demand more external sources of knowledge and information than general innovation (Brown et al., 2020; Chistov, Carrillo-Hermosilla, et al., 2023; Pichlak & Szromek, 2021). This growing understanding that one firm might not have all the necessary experience, tools, and resources to implement sustainable changes has prompted a surge in research within the academic and professional communities (Araújo & Franco, 2021; Melander, 2017; Pereira et al., 2020), ultimately leading to the emergence of a new concept of Open Sustainable Innovation (OSI) (Bogers et al., 2020; Cappa et al., 2016; Kimpimäki et al., 2022; Rauter et al., 2017). In general terms, it refers to the use of open innovation strategies, including collaboration and sourcing external knowledge to support the internal development of sustainable innovations (Bogers et al., 2020; Rauter et al., 2017). The increasing body of theoretical and empirical research demonstrates the potential of OSI to reconcile the economic and environmental objectives of organizations, contributing to the sustainable transition of society (Kiefer et al., 2021; Russo Spena & Di Paola, 2020). Despite the great potential of OSI, we still have a very limited understanding of the concept (Bigliardi & Filippelli, 2022; Camilleri et al., 2023; Sanni & Verdolini, 2022). Therefore, further investigation is needed to explore its origins, theoretical foundations, and the determinants of its successful adoption and implementation.

## **1.2 Research Objectives and Structure**

This dissertation examines the complex relationship between sustainability orientation, innovation, and business performance. It also seeks to deepen the understanding of the connection between a specific type of sustainability-oriented innovations - eco-innovations and open innovation strategy and investigates the emergence of a new line of research on Open Eco-innovation (OEI). Accordingly, we formulate the following research objectives:

**RO1:** Explore the relationship between firms' sustainability orientation and business performance.

**RO2:** Explore the role of innovation in the relationship between sustainability orientation and business performance.

**RO3:** Explore a particular type of sustainability-oriented innovation (i.e., Eco-innovation) from a perspective of open innovation (i.e., Open eco-innovation).

In Chapter 2, we delve into the available theoretical perspectives and empirical evidence surrounding the relationship between sustainability orientation and business performance. Additionally, we explore the literature on the interplay between sustainability and innovation. To provide a more focused analysis, we concentrate on a specific representation of sustainable innovation known as eco-innovation, delving into the unique characteristics that set it apart from other types of innovations. Moreover, we examine the challenges that arise during the development and implementation of eco-innovation initiatives. To conclude this section, we review literature suggesting that organizations can overcome the inherent challenges of eco-innovation through open innovation strategies, such as collaboration and knowledge sourcing from external stakeholders. Notably, these strategies become particularly relevant when organizations strive for more radical environmental objectives.

The general research strategy is presented in Chapter 3 of this dissertation. It includes an explanation of the employed research methodological approaches, as well as insights into how the investigations were carried out. In addition, it provides an outline of the three manuscripts that comprise this thesis and shows the interrelationships among them. The chapter also provides an overview of research problems addressed in each study and the research questions each one of them contributes to answer.

Chapters 4, 5, and 6 form the core of this dissertation, encompassing the three individual studies. All of them were presented at international conferences. Notably, Paper 1 received the distinction of the best paper award at the ACEDE-Gem Conference in 2023. In accordance with the Doctoral program's criteria, all of the manuscripts have undergone peer review and have been successfully published in indexed international journals.

Chapter 7 serves as a synthesis of the findings derived from our studies, offering a comprehensive analysis of their collective outcomes. It presents our theoretical contribution to the literature on sustainability and open eco-innovation. It also summarises the practical implications of the results of our work for organizations and policymakers that search for ways to integrate sustainability, innovation, and business performance.

Chapter 8 provides a final conclusion to the dissertation. It also critically examines the limitations inherent to each study and the dissertation as a whole. Consequently, it highlights the potential avenues for further investigation for researchers and practitioners interested in

advancing the understanding of the relationship between sustainability orientation, innovation, business performance, and open innovation.

## 2. THEORETICAL BACKGROUND: CHALLENGES OF THE SUSTAINABILITY TRANSITION

The transition toward a more sustainable future is a complex and comprehensive process that involves the restructuring of economic, social, and environmental systems while simultaneously facing numerous challenges (Markard et al., 2020). In their seminal work, Köhler et al. (2019) suggest that the sustainability transition has several special characteristics that make it a different and demanding topic in the sustainability literature. *First*, sustainability issues are multi-dimensional and involve multiple actors. They are complex and interconnected, making it challenging to address them coherently and effectively (Kiefer et al., 2021). Consequently, these challenges cannot be overcome solely through the efforts of individual organizations or even countries; rather, they require a collective and collaborative approach from all sectors of society (Curley & Salmelin, 2018). In other words, they require a more systemic rather than a linear approach. *Second*, the sustainability transition is a long-term process. However, the prevailing dominance of “short-termism” in the modern world prioritizes the immediate goals of political elites seeking re-election and businesses striving for annual profit maximization on behalf of shareholders. Consequently, short-term objectives are often given priority over long-term sustainability goals (Slawinski et al., 2017). *Third*, the transition towards sustainability carries the duality between stability and change. The urgent environmental issues frequently demand radical changes in production, consumption, and waste management practices. However, existing institutional structures, such as legal frameworks, financial systems, and governance mechanisms, may not be specifically designed to support sustainability objectives (Polzin et al., 2016; Unruh, 2000). *Fourth*, the sustainability transition requires substantial shifts in societal values, behaviors, and lifestyles. This can prove challenging, as individuals are often resistant to change and may harbor conflicting priorities and interests (Curley & Salmelin, 2018; Esposito et al., 2022). *Fifth*, the development and widespread implementation of sustainable technologies are crucial in achieving sustainability goals. Yet, various technological challenges, such as scalability, affordability, and technological readiness, need to be overcome (Derks et al., 2022; Häggmark & Elofsson, 2022). *Sixth*, the sustainability transition relies heavily on access to knowledge and information, including scientific research, data, and best practices. However, knowledge gaps and limited access to relevant information often hinder progress (Awan et al., 2021; De Marchi & Grandinetti, 2013; Wu, 2022). *Finally*, companies may be hesitant to invest in sustainability solutions due to concerns regarding costs and competitiveness (Le & Ikram, 2022; Porter &

Linde, 1995). Economic interests, such as profit maximization and economic growth, may clash with sustainability goals (Chowdhury et al., 2023).

The challenges surrounding the sustainability transition have led to differing perspectives within the academic community. One camp holds a more traditional view, suggesting that sustainability and intensive human economic and production activities are incompatible (Büchs & Koch, 2019; Kallis, 2011). On the other hand, the "revisionist" approach, advocated by Aragón-Correa & Rubio-López (2007), Porter & Kramer (2011), Porter & Linde (1995), Shrivastava (1995), proposes the possibility of a win-win relationship between sustainability objectives and economic prosperity for organizations and society at large. This dissertation adopts a "revisionist" perspective and focuses on examining the link between sustainability and business performance. Contrary to concerns that the introduction of sustainability objectives may have a negative impact on the firm's performance, the aim of this work is to demonstrate that, in the long run, sustainability orientation can contribute to business performance and growth. Furthermore, we explore the relationship between sustainability and innovation, particularly in the form of eco-innovation, from an open innovation approach (i.e., open eco-innovation).

## **2.1 Sustainability and Business Performance**

There exist multiple perspectives on the relationship between organizations and sustainability. One is that businesses have a moral and ethical responsibility to prioritize sustainability, regardless of the immediate financial impact (Friedman, 1970; Ha-Brookshire, 2017; Handy, 2022; Torelli, 2021). A more radical perspective argues that the current overexploitation of natural resources and accumulated social issues cannot sustain desired economic growth anymore and that the pursuit of profit and growth contradicts the search for sustainability (Büchs & Koch, 2019; Cosme et al., 2017; Demaria et al., 2013; Kallis, 2011). Other researchers take a more pragmatic approach, stating that businesses will only pursue sustainable practices if they do not interfere with their bottom line. Finally, the proponents of the "revisionist" view argue that the introduction of sustainability practices can actually be profitable and lead to a long-term competitive advantage (Aragón-Correa & Rubio-López, 2007; Chowdhury et al., 2023; Porter & Kramer, 2011).

There are several ways in which sustainability-oriented firms (organizations that adopt environmental or social values and objectives (Khizar et al., 2021; Kuckertz & Wagner, 2010)) may benefit from sustainability practices. For instance, such practices may lead to considerable cost savings and improved profitability through increased efficiency, reduced material, and energy consumption, and reduced production of waste (Antikainen et al., 2018; Silvestri et al., 2022). Also, when firms pursue sustainability objectives, they often have to develop new capabilities, such as stakeholder management (Torugsa et al., 2012), knowledge management and absorptive capacity (Aboelmaged & Hashem, 2019), alliance and networking capabilities (Inigo et al., 2020), as well as dynamic capabilities such as sensing (search for valuable external knowledge), and ability to transform and realign the organization to integrate sustainable practices (Bogers et al., 2019). The new capabilities may play an essential role in firms' long-term success (Grewatsch & Kleindienst, 2017). In addition, according to the natural resource-based view (Hart, 1995), sustainability orientation may encourage firms to acquire or develop valuable and hard-to-imitate resources, which may contribute to long-term competitive advantage (Lei et al., 2019). Furthermore, sustainable practices contribute to a positive reputation and higher legitimacy of the firm, which may lead to higher market share, new customers, and revenue streams (De Castro et al., 2006; Truong & Nagy, 2021). Finally, sustainability-orientated organizations may be better prepared to meet changing market demands and societal expectations, ensuring long-term business success (Bogers et al., 2019; del Río, 2005). Therefore, the recent literature considers sustainability orientation as one of the major sources of competitive advantage for the firm (Aragón-Correa et al., 2008; Aragón-Correa & Sharma, 2003; Sharma & Vredenburg, 1998)

Despite the theoretically determined potential benefits of sustainability orientation for business performance, in reality, only a small proportion of organizations tend to pursue sustainability objectives (Chistov et al., 2023; Cohen & Winn, 2007). As a result, there exists a significant lack of empirical evidence on the matter. For instance, some studies found that sustainability orientation may have a significant positive effect on various business and financial performance measures (Bodhanwala & Bodhanwala, 2018; Gómez-Bezares et al., 2017; Soto-Acosta et al., 2016). Other studies showed that sustainability objectives might actually hurt the organizations, pointing to a possible win-lose situation (Linder et al., 2014; López et al., 2007; Stevens et al., 2015). Other researchers, however, argue that it is impossible to test this relationship due to the multiple contextual factors that may moderate it, such as the

type of sustainability objectives (i.e., environmental vs. social), the age and maturity of an organization, innovation pursuits (Margolis & Walsh, 2001).

Therefore, the relationship between sustainability orientation and business performance is not clear, giving rise to the following research questions:

- ❖ **RQ1:** What is the relationship between sustainability orientation and business performance? In particular, how do environmental and social orientations (i.e., setting environmental and social objectives) affect business performance?
- ❖ **RQ2:** What are the long-term implications of sustainability orientation (both environmental and social) for the firm's performance and growth?

Study 1 intends to bring additional empirical evidence to understand the relationship between sustainability orientation and business performance, aiming to answer the previous research questions.

## **2.2 Sustainability and Innovation**

One of the most important and extensively explored drivers of the business performance of organizations is innovation (Mousavi et al., 2018). While some studies adopt a cautious approach when establishing a definitive positive relationship between sustainability and innovation (Löfsten, 2014), a majority of empirical evidence supports the notion that innovation significantly enhances a firm's performance (Gunday et al., 2011; Han et al., 1998; Rajapathirana & Hui, 2018). Introducing new products, for instance, can strengthen a firm's competitive position and lead to increased market share (Löfsten, 2014) and profitability (Sakchutchawan et al., 2011). Similarly, changes in the production process can improve efficiency, reduce costs, and enhance product quality (Rabadán et al., 2019; Tukker & Ekins, 2019). Additionally, innovative business models can create new revenue streams, disrupt existing markets, and even give rise to entirely new markets (Bocken, 2019; Boons & Lüdeke-Freund, 2013; Peralta et al., 2019). Innovation can exert an indirect influence on business performance as well. Research suggests that innovative firms possess distinct characteristics that set them apart, such as proactiveness, risk-taking, a willingness to challenge established business practices, and an openness to new ideas, modes of operation, and business models (Ge et al., 2016). Moreover, multiple empirical studies have emphasized the particular importance

of innovation during times of economic turbulence and uncertainty (Turulja & Bajgoric, 2019). Consequently, innovation has proven to have a significant positive effect on a firm's competitive advantage and overall business performance (Sakchutchawan et al., 2011).

The relationship between innovation and sustainability is a topic of ongoing research within academic literature, abundant with varying perspectives and points of view. Nonetheless, it is widely recognized as an essential component in addressing the urgent social and environmental challenges we face today and driving the sustainability transition (Arekrans et al., 2022; Klewitz & Hansen, 2014; Schaltegger & Wagner, 2011). Studies indicate that innovation in sustainability-oriented businesses offers several benefits, including differentiation from competitors, improved cost structures, enhanced reputation with consumers and stakeholders, and the establishment of long-term competitive advantages (Allal-Chérif et al., 2023; Aragón-Correa & Sharma, 2003; Hart, 1997; Weng et al., 2015). Ultimately, innovation is seen as a vital element in resolving the inherent tensions that arise when companies strive to reconcile environmental, social, and financial objectives (Matzembacher et al., 2020; Souto, 2022). Some studies support these assertions, indicating that innovation positively moderates and mediates business growth when firms pursue environmental objectives (Ben Amara & Chen, 2020; Wang et al., 2021) as well as when they pursue social objectives (Guerrero-Villegas et al., 2018; Hull & Rothenberg, 2008; Wang, 2022). However, despite these valuable insights, the available empirical evidence on the relationship between innovation and sustainability remains limited, emphasizing the need for further research to comprehend the complex dynamics at play (Demirel & Danisman, 2019; Klewitz & Hansen, 2014).

Our Study 1 intends to uncover new insights from the empirical evidence on the relationship between sustainability orientation, innovation, and business performance, addressing the following research questions:

- ❖ **RQ3.** What is the relationship between sustainability orientation (both environmental and social) and innovation?
- ❖ **RQ4.** Does innovation moderate the relationship between sustainability orientation (both environmental and social) and business performance?

### 2.2.1 The Concept of Eco-innovation

The widely accepted metaphor of the triple bottom line suggests that sustainability-oriented organizations simultaneously pursue social, environmental, and economic objectives (Elkington, 1998). Consequently, recent literature has examined sustainability as a unified and all-encompassing concept that includes these three goals (Belz & Binder, 2015; Klewitz & Hansen, 2014). This generalization is justified by the belief that social and environmental goals are often complementary, leading to shared challenges and opportunities (Schaltegger & Wagner, 2011). Nevertheless, historically these concepts were examined separately (Thananusak, 2019). Our Study 1, along with indications from the literature (York, 2009), suggests that social and environmental challenges have distinct natures. Social orientation is often rooted in the non-profit sector, prioritizing public benefit over business objectives in general (Hoogendoorn et al., 2019). On the other hand, environmental objectives often directly align with business goals by reducing energy and material costs and avoiding government penalties (York, 2009). Considering this, in our research, we separate sustainability orientation into social and environmental orientation and then explicitly focus on the relationship between environmental orientation, innovation, and business performance.

When environmentally-oriented organizations employ innovations and, as a result, can decrease their environmental impact, those types of innovations are referred to as eco-innovation (Carrillo-Hermosilla et al., 2010). This is a type of sustainable innovation, and it includes both the process of developing environmental solutions as well as the solutions themselves (product or service). It encompasses both technological and non-technological changes, including organizational structures and business models, consumption habits, and production systems (Kulak et al., 2016; Machiba, 2010). Eco-innovation plays a vital role in transitioning our society toward a more sustainable future (Markard et al., 2012) while also contributing to the long-term success of firms (Boons & Lüdeke-Freund, 2013).

Eco-innovations, as highlighted by Gutierrez-Gutierrez et al. (2020), exhibit distinct characteristics that set them apart from other types of innovations. Most importantly, it is characterized by its ability to decrease the environmental impact of organizations rather than reaching purely commercial objectives (Carrillo-Hermosilla et al., 2009). Also, firms that engage in eco-innovation foster value co-creation with various societal actors relying on the skills, competencies, and resources of stakeholders (Phillips et al., 2019). By collaborating and leveraging external expertise, these organizations enhance their innovation potential and foster

broader societal benefits. Furthermore, eco-innovation is inherently knowledge-intensive, driven by the pursuit of solutions to complex issues that have not been adequately addressed in the past. This requires leveraging knowledge and expertise from various disciplines, balancing the goal of enhancing firm competitiveness while addressing grand sustainability challenges (Chaurasia et al., 2020; De Marchi & Grandinetti, 2013). Lastly, eco-innovation adopts a long-term orientation, acknowledging that significant social and environmental challenges demand sustained efforts over extended periods for effective resolution (Flammer & Bansal, 2017; Gao & Bansal, 2013).

Consequently, firms embarking on eco-innovations often encounter significant barriers across different dimensions. Externally, these barriers may arise from the lack of proper institutional structures and insufficient pressure from stakeholders, impeding the progress of eco-innovation initiatives. Internally, firms may face challenges related to limited financial resources, a lack of knowledge and skills necessary to implement environmental solutions, and potential incompatibilities with existing production processes or business models (del R  o et al., 2010).

One of the possible ways to overcome barriers and challenges associated with eco-innovation is through collaboration with external institutions, organizations, and individuals (Ara  jo & Franco, 2021; Ardito et al., 2019; Melander & Pazirandeh, 2019). Empirical studies conducted in the past decade have consistently highlighted the significance of collaboration in the context of eco-innovation (De Marchi, 2012; Mazzanti & Zoboli, 2009; Rennings & Rammer, 2011; Wagner, 2009). They demonstrate that eco-innovation, given its systemic and complex nature, requires greater cooperation compared to other forms of innovation, emphasizing the importance of leveraging the competencies of external partners (De Marchi, 2010). Furthermore, successful eco-innovations are found to rely heavily on the participation of diverse stakeholders, highlighting the value of collaboration between the public sector, academia, and businesses (Acebo et al., 2021; Velter et al., 2019; Wiesmeth, 2020). Collaboration also emerges as a critical competence in the design process of the circular economy, wherein different forms of cooperation can influence the transformative potential of circular innovations (Brown et al., 2020; Eisenreich & F  ller, 2023; Mishra et al., 2021). Recent research further positions inter-organizational collaboration within the realm of open innovation strategies, which encompass a comprehensive approach for organizations to utilize external resources, both tangible and intangible, in the development and commercialization of

eco-innovations (Civelek et al., 2020; González-Moreno et al., 2019; Leitão et al., 2020; Triguero et al., 2018).

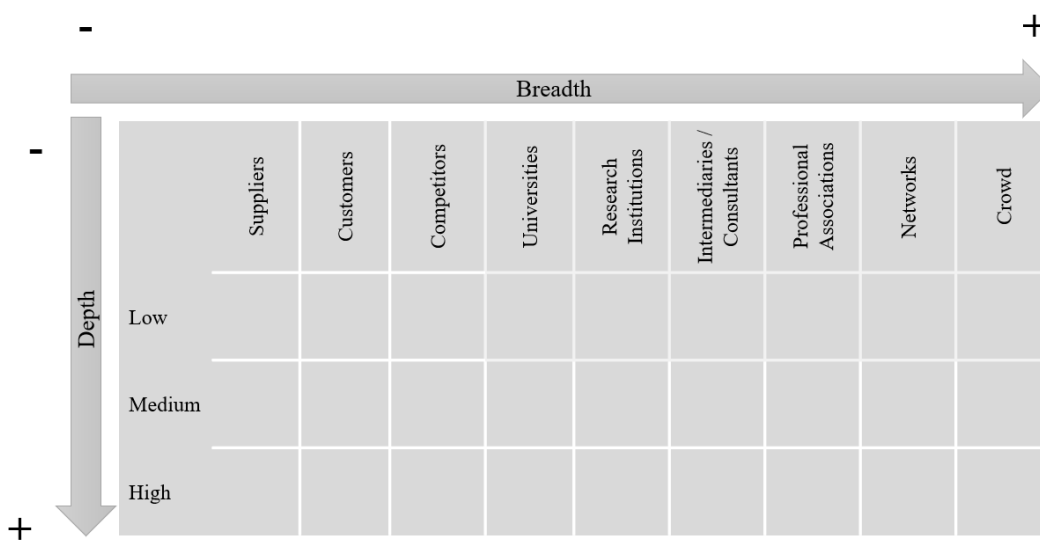
### 2.2.2 *The Concept of Open Eco-innovation*

There is no universally established definition of open eco-innovation (OEI), but broadly speaking, it refers to the use of open innovation strategies to develop eco-innovations (Civelek et al., 2020; Naruetharadhol et al., 2021). It encompasses a set of approaches, tools, and modes to share knowledge and resources among several companies in order to reduce their cumulative environmental impact (Ghisetti et al., 2015; Winston, 2010). In our Study 2 (Chistov et al., 2021, p. 3), we used the definitions of open innovation by Chesbrough (2003) and eco-innovation by Carrillo-Hermosilla et al. (2010) and formulated that Open Eco-innovation is “a purposive use of inflows and outflows of knowledge, resources, and commercialization paths to develop and/or adopt innovations that improve the environmental performance of the firm.” This implies that organizations can and should intentionally manage the flows of knowledge and resources across their borders to enhance internal eco-innovation development (Camilleri et al., 2023; De Marchi, 2012; Kobarg et al., 2020), as well as commercialize their eco-innovative know-how through proper intellectual property management (Cheng & Shiu, 2020; Leitão et al., 2020). As a result, organizations can supplement the lack of internal knowledge and resources (Dimakopoulou et al., 2022; Krom et al., 2022), address the major barriers to eco-innovation (Kiefer, Del Río González, et al., 2019; Pinget et al., 2015), and even deal with the issue of double externality and involuntary knowledge spillovers (Hansen & Klewitz, 2012). Additionally, they can generate new cash flows and revenues through the sale or licensing of intellectual property, promoting the diffusion of new eco-innovations within their and other compatible industries (Camilleri et al., 2023; Melander & Wallström, 2022).

Open Eco-innovation may take several forms and modes based on the sources of knowledge the organization chooses to draw the information from, the number of sources and partners they chose to work with at a time (the breadth of OEI), and the intensity of their relationships (the depth of OEI) (See Fig. 1) (Ghisetti et al., 2015; Gutierrez-Gutierrez et al., 2020). One basic form of OEI is the simple purchase of green technologies through licenses and patents without the need for formal partnerships (Kanda et al., 2016). It may also include participation in industry conferences and events, which provide opportunities to stay up to date

on the newest trends in eco-innovation and foster networking and collaboration (McGahan et al., 2021). Understanding client preferences is a critical component of OEI, which may be accomplished through surveys, focus groups, and other similar techniques that enable co-creation with customers (Eisenreich & Füller, 2023; Wiesmeth, 2020). Furthermore, organizations might develop more formal collaborations with stakeholders such as suppliers, universities, customers, and research institutes. Such partnerships can provide new information and experience and generate opportunities for the co-creation of novel solutions (Ardito et al., 2019; Chavez et al., 2023; Christensen et al., 2019). Firms may also participate in projects and programs run by the government that can assist the establishment of consortiums with a variety of stakeholders and provide the necessary contacts and funding (Bongaerts & Heinrichs, 1987; Hermann et al., 2016; Van Luin & Van Starckenburg, 1988). Organizations can also get ideas from a large network of individuals and organizations by implementing open innovation platforms and technologies and exploring the benefits of crowdsourcing and crowdfunding (Hörisch, 2018; Petruzzelli et al., 2019; Tenner, 2021). Finally, the recent OEI research looks at the possibility of developing sustainable ecosystems and value networks, that involve a diverse set of institutional and business players (Aka, 2019; Breuer & Lüdeke-Freund, 2017; Melander & Pazirandeh, 2019).

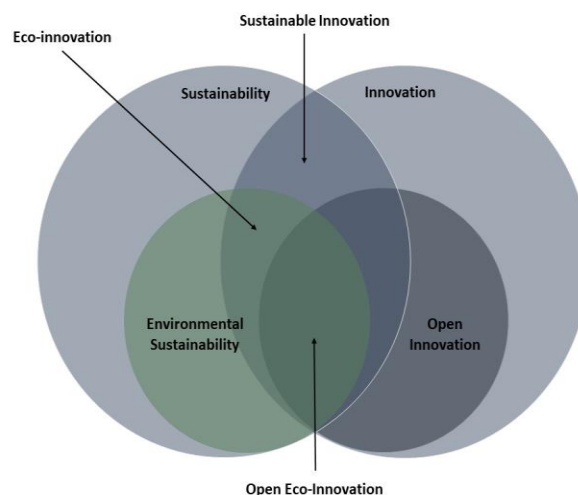
Figure 1. The Depth and Breadth of Open Eco-innovation



Source: Author’s elaboration based on Gutierrez-Gutierrez et al. (2020)

Multiple recent literature reviews and bibliometric studies (Araújo & Franco, 2021; Bigliardi & Filippelli, 2022; Camilleri et al., 2023; Pereira et al., 2020; Sanni & Verdolini, 2022) showed that the research into OEI has gained significant academic interest in the last decade. They also indicated that the concept is emerging from two research domains: sustainable development with a focus on firms' environmental objectives and innovation management, particularly open innovation studies (see Fig. 2). The origins of OEI can be traced back to eco-innovation literature that explored the benefits of collaboration and external knowledge sources in developing sustainable solutions. In fact, the importance of different facets of open innovation (as we know it today) was documented long before the introduction of the term "open innovation" by Henry Chesbrough in 2003. In the 80s and 90s, most of the R&D and further implementation of clean technologies happened through extensive collaboration among universities, research centers, and companies, subsidized by national governments (Bongaerts & Heinrichs, 1987; Georg et al., 1992). Cooperation and access to external knowledge and resources have long been considered and proved empirically to be essential drivers of eco-innovation (Mazzanti & Zoboli, 2009; Wagner, 2009). However, over the past decade, researchers in the open innovation field also have increasingly explored its potential for advancing sustainability as well (Bogers et al., 2020; Chesbrough & Di Minin, 2014; Curley & Salmelin, 2018). As a result, we are currently witnessing the emergence of a new research stream that stems from eco-innovation and open innovation disciplines (Urbinati et al., 2023).

Figure 2. Conceptualization of Open Eco-innovation.



Source: Author's elaboration.

OEI may appear as a straightforward process, but in reality, it is a complex phenomenon (Leitão et al., 2020; Valdez-Juárez & Castillo-Vergara, 2020) that spans several disciplines, draws from a variety of economic and management theories and approaches (Acebo et al., 2021; Yu et al., 2019), and is characterized by ambiguous terminology (Urbinati et al., 2023). In addition, due to its novelty and the ongoing nature of research in this area, the concept is still not well-defined, conceptualized, or situated within the sustainability and management literature (Bigliardi & Filippelli, 2022; Kimpimäki et al., 2022; Sanni & Verdolini, 2022). This fragmented understanding of the phenomenon makes it challenging for researchers and practitioners to grasp its multifaceted nature and potential implications fully.

Considering the aforementioned, the following research questions arise:

- ❖ **RQ5:** What are the different approaches to the study of open eco-innovation?
- ❖ **RQ6:** What is the relationship between open innovation and eco-innovation? And how does one affect the other?

Studies 2 and 3 address these research questions. Study 2 comprises a bibliometric analysis of the research into OEI aiming at identifying the main topics and approaches in the study of this concept, contributing to answering research question 5. Study 3 investigates how an open innovation approach affects eco-innovation (research question 6).

### **3. RESEARCH STRATEGY**

#### **3.1 Epistemological Stance**

The research strategy adopted in this dissertation primarily embraces the principles of the positivist research paradigm. It holds that knowledge is optimally obtained through an objective, empirical investigation that utilizes quantifiable evidence collected via structured, formal, and rigorous methods (Rehman & Alharthi, 2016). While numerous studies have attempted to understand the relationship between sustainability orientation and business performance in a more theoretical manner, adhering to interpretivism or a constructivist paradigm, we discovered a significant gap in empirical studies examining this relationship. We saw a need for research employing extensive datasets to evaluate a firm's potential for improving performance and growth when adopting sustainability objectives. This was equally applicable to the connection between open innovation and eco-innovation. Our research employs a systematic analysis of data from extensive databases with the aim of generating accurate, valid, and replicable findings that augment the existing body of knowledge. By embracing the positivist approach, we strive to provide objective interpretations and precise explanations of these relationships. Our goal is to uncover the underlying patterns and principles devoid of researcher bias. Furthermore, our methodology allows for replication with various sub-samples of data, such as different countries, industries, firm sizes, etc. This replication permits the drawing of additional insights by comparing results and observing the behavior of various variables within different samples and contexts.

Although primarily driven by the positivist paradigm, this dissertation also incorporates elements of the critical research paradigm. This paradigm emphasizes the significance of power dynamics, societal inequalities, and social change, scrutinizing societal structures with a view to fostering a more equitable and just society (Asghar, 2013; Cooper, 1997). Acknowledging the intricate connections between businesses, the environment, and society, we critically evaluate organizations' role within these interdependent systems. More specifically, the research investigates the power dynamics, ethical considerations, and societal implications inherent in the relationship between an organization's environmental orientation and business performance. As part of this analysis, we delve into the uneven distribution of environmental responsibilities and the potential of eco-innovation to redress social inequalities, reduce environmental degradation, and encourage sustainable business practices. Thus, the study stimulates a critical discourse concerning prevailing business models, aspiring to spark change

by advocating for open eco-innovation strategies. This aligns with the critical paradigm's focus on advancing a more equitable society. Consequently, while our primary analysis adheres to the rigorous, objective methods of positivism, our research questions, discussion, and conclusions are influenced by a critical perspective.

### **3.2 Research Design**

This dissertation aims to explore the complex relationship between sustainability orientation, innovation, and business performance and the crucial role of open innovation strategies in fostering eco-innovations. It primarily focuses on firms across a range of industries and sectors in Spain, with a particular emphasis on small entrepreneurial ventures (as per Study 1) and small to large firms (as explored in Study 3). The research unfolds on several levels of analysis, incorporating the micro-level, which corresponds to the internal environment of organizations (Study 1), the meso-level that deals with inter-organizational relationships (Study 3), and a comprehensive micro-meso-macro level explored in Study 2.

To address our research questions surrounding the interrelation of sustainability orientation, innovation, and business performance, we utilize data from the 2019 Global Entrepreneurship Monitor (GEM). This data set was previously employed to investigate the environmental orientation of new ventures (Hörisch et al., 2019), the determinants of social entrepreneurship (Canestrino et al., 2020; Leković et al., 2021), and the performance of green entrepreneurship (Yin et al., 2022). Our sample consisted of 2,254 established Spanish entrepreneurial firms from a variety of industries. For the exploration of the relationship between Open Innovation and Eco-innovation, our research draws on data from the Spanish Technological Innovation Panel (PITEC), a survey managed by the National Institute of Statistics in Spain (INE) and the Spanish Foundation for Science and Technology (FECYT). Given its extensive reach, PITEC is frequently used as an empirical data source in literature on Eco-innovation and open innovation (De Marchi, 2012; del Río et al., 2016; Ghisetti et al., 2015; Horbach et al., 2012). We employed the most recent available dataset from 2016. After excluding firms with employment fluctuations due to mergers, acquisitions, or high labor turnover (Acebo et al., 2021; González-Pernía et al., 2015) and those failing to report their eco-innovation activities, our sample comprised 2,934 firms. The data from Spain was selected for this study due to its position roughly in the middle of the European countries ranking in the

Sustainable Development Report, specifically ranking 16 in 2022 (Sachs et al., 2022). This choice allows for a representative analysis of a country with average sustainability efforts. Furthermore, our methodology can be easily applied to other countries that have adopted the Community Innovation Survey (CIS), enabling the replication of this study on a broader scale. Lastly, for our bibliometric review of research in Open Eco-innovation (Study 2), we utilized bibliometric data from the Web of Science and Scopus databases, examining a sample of 538 articles published up until 2021.

### **3.3 Research Methods**

Following the positivist paradigm, we adopted a quantitative approach to address our research questions. Study 1 utilized a binomial logistic regression analysis. It estimates the probability of the firm to grow, both in terms of turnover and employment. The logistic model,  $\ln P/(1 - P_i) = \beta X_i$ , was employed to predict the proportion and the logarithmic odds of this event, which is linearly influenced by a vector of covariates  $X_i$  with coefficient vector  $\beta$ . The covariates encompassed the main independent variables (sustainability orientation, environmental orientation, social orientation), the moderating variable (innovation), and the control variables. Study 2 adopted a quantitative and systematic approach to the literature review and used bibliometric tools and software to analyze the current developments in the academic literature on the concept of OEI, including the overview of key contributions, authors, and topics that constitute the debate. Lastly, in Study 3, we employed another binomial logistic regression to examine the relationship between the binary dependent variables (various types of eco-innovation objectives and their levels of radicalness) and multiple independent variables (such as cooperation and various sources of knowledge). This regression model allowed us to estimate the log(odds) of a firm pursuing a particular level of eco-innovation radicalness to employ some type of OEI strategy and source knowledge from a particular external partner. All models were tested for robustness and proved to show reliable and consistent results.

### **3.4 The Overview of Included Studies**

*Study 1* addresses a broader notion of sustainability and its effect on the business performance and growth of the firm. It explores whether organizations (entrepreneurial

ventures in particular) can simultaneously reach both sustainability and business objectives and whether embracing sustainability orientation can serve to promote firms' growth. Based on the data from 2 370 firms, we conclude that the relationship between sustainability orientation and a firm's growth is not straightforward. Our results suggest that established, mature firms are more likely to grow when they incorporate sustainability objectives into their business strategy. However, this relationship does not hold among their younger counterparts. We also found that a positive effect of sustainability orientation on performance appears only among firms with environmental but not social orientation. Finally, we underline that in our sample, only 1 in 10 companies pursue sustainability objectives. We conclude that while sustainability orientation (and environmental orientation in particular) may be a positive force to drive the business performance and the growth of the firm, the complexity of development and integration of sustainability solutions and the lack of knowledge, resources, and capabilities hinder firms from recognizing its benefits and delay implementation. This, in turn, slows the overall sustainability transition of our society.

*Study 2* delves into the concept of Open Eco-innovation. Employing bibliometric analysis techniques, the study investigates its origins, offering a quantitative assessment of the literature spanning from the early 1990s to 2020. The findings reveal a marked increase in research interest, especially from 2010. The study unifies fragmented research derived from the literature on open innovation and eco-innovation under the comprehensive term "Open Eco-innovation." Furthermore, it identifies the main topics studied in the research on OEI as well as the main perspectives from which the OEI phenomenon has been studied (i.e., micro-, meso-, and macro-perspectives).

*Study 3* empirically examines empirically how an open innovation approach affects eco-innovation. Based on a sample of 2,934 Spanish firms from a wide range of industries, this work demonstrates that an open innovation strategy is essential when firms pursue eco-innovations, especially when seeking radical solutions. It shows that the significance of an open approach fluctuates based on the forms of opening (cooperation versus sourcing external knowledge), the selection of knowledge partners, and the intended level of eco-innovation radicalness. This paper addresses a lack of research regarding the selection of appropriate forms of knowledge sourcing and the selection of knowledge partners for each level of eco-innovation radicalness. The findings also indicate a potential misalignment between the significance of

open innovation in the development of innovative and impactful environmental solutions and the small proportion of organizations adopting this innovation strategy.

Table 1. Overview of Manuscripts.

	<b>Manuscript 1</b>	<b>Manuscript 2</b>	<b>Manuscript 3</b>
<b>Title</b>	<b>Sustainability orientation and firm growth as ventures mature</b>	<b>Open Eco-innovation: A Bibliometric Review of Emerging Research</b>	<b>Open Eco-innovation. Aligning Cooperation and External Knowledge with the Levels of Eco-innovation Radicalness</b>
<b>Research Object</b>	Small firms / entrepreneurial ventures in Spain	The concept of Open Eco-innovation	Small, medium, and large firms in Spain
<b>Level of Analysis</b>	Micro-level	Micro-meso-macro level	Meso-level
<b>Research Subject / Problem</b>	<ul style="list-style-type: none"> <li>■ Low proportion of new ventures pursuing sustainability goals</li> <li>■ The existing research does not provide a definitive answer if sustainability orientation can positively affect the firm's business performance and growth</li> </ul>	<ul style="list-style-type: none"> <li>■ The lack of structured research into the concept of Open Eco-innovation</li> </ul>	<ul style="list-style-type: none"> <li>■ The scarcity of empirical research examining the effect of an open innovation approach on eco-innovation.</li> </ul>

<p><b>Research Questions</b></p>	<ul style="list-style-type: none"> <li>■ <b>RQ1:</b> What is the relationship between sustainability orientation and business performance? Particularly, how do environmental and social orientation affect business performance?</li>   <li>■ <b>RQ2:</b> What are the long-term implications of sustainability orientation for the firm's performance and growth? Particularly how does it affect the growth in terms of turnover and employment?</li>   <li>■ <b>RQ3:</b> What is the relationship between Sustainability Orientation (both environmental and social) and Innovation?</li>   <li>■ <b>RQ4:</b> Does Innovation moderate the relationship between Sustainability Orientation (both environmental and social) and Business performance?</li> </ul>	<ul style="list-style-type: none"> <li>■ <b>RQ5:</b> What are the different approaches to the study of open eco-innovation (OEI)?</li> </ul>	<ul style="list-style-type: none"> <li>■ <b>RQ6:</b> What is the relationship between open innovation and eco-innovation? And how does one affect the other?</li> </ul>
<p><b>Research Design</b></p>	<ul style="list-style-type: none"> <li>■ Type: Quantitative</li>   <li>■ Data: Global Entrepreneurship Monitor (GEM) - 2019</li> </ul>	<ul style="list-style-type: none"> <li>■ Type: Quantitative</li>   <li>■ Data: Web of Science and Scopus database - 2021</li> </ul>	<ul style="list-style-type: none"> <li>■ Type: Quantitative</li>   <li>■ Data: Panel de Innovación Tecnológica (PITEC) - 2016</li> </ul>

	<ul style="list-style-type: none"> <li>■ Sample: 2 254 firms</li> <li>■ Method: Logistic Regression</li> </ul>	<ul style="list-style-type: none"> <li>■ Sample: 538 academic articles</li> <li>■ Method: Bibliometric Analysis</li> </ul>	<ul style="list-style-type: none"> <li>■ Sample: 2 934 firms</li> <li>■ Method: Logistic Regression</li> </ul>
<b>Main Findings</b>	<ul style="list-style-type: none"> <li>■ Sustainability orientation (environmental orientation in particular) is positively related to firm growth in terms of turnover and employment, however, only among mature firms.</li> <li>■ In contrast to environmental orientation, social orientation did not show any positive effect.</li> <li>■ Only a very small percentage of firms tend to pursue sustainability objectives.</li> </ul>	<ul style="list-style-type: none"> <li>■ Identification of main authors and studies on OEI.</li> <li>■ Identification of different approaches to the study on OEI (i.e., macro-, meso-, micro-levels).</li> </ul>	<ul style="list-style-type: none"> <li>■ The radicalness of eco-innovation is not a dichotomy but a spectrum that can be presented through frameworks with several-level based on the degree of radicalness.</li> <li>■ A more comprehensive analysis of the role of open innovation in developing eco-innovation is needed, taking into account the differences between active cooperation and external knowledge sourcing and how they affect the radicalness of eco-innovation.</li> <li>■ This study offers a more nuanced understanding of the impact of cooperation on eco-innovation (EI) radicalness, highlighting that cooperation is positively associated with most levels of EI radicalness except material consumption efficiency and reinforcing the importance of cooperation for introducing radical solutions to complex environmental issues.</li> </ul>

<b>Publication year</b>	2023	2021	2023
<b>Authors</b>	Valery Chistov, Nekane Aramburu, María Eugenia Fabra Florit, Iñaki Peña-Legazkue, Pauline Weritz	Valery Chistov, Nekane Aramburu, Javier Carrillo-Hermosilla	Valery Chistov, Javier Carrillo-Hermosilla, Nekane Aramburu
<b>Journal</b>	Business Strategy and the Environment	Journal of Cleaner Production	Journal of Open Innovation: Technology, Market, and Complexity
<b>Ranking</b>	JCR, Q1	JCR, Q1	SJR, Q1
<b>Conference Participation</b>	<ul style="list-style-type: none"> <li>■ ACEDE, Valencia (2022). <b>Best Paper Award.</b></li> <li>■ International Workshop on ESG Values (IWESGV), San Sebastian (2023)</li> <li>■ ACEDE, Alicante (2023)</li> </ul>	<ul style="list-style-type: none"> <li>■ ACEDE, Granada (2019)</li> <li>■ GRONEN, Lisbon, (2020)</li> </ul>	<ul style="list-style-type: none"> <li>■ Eco-innovation Society Workshop, (2022)</li> <li>■ New Business Models Conference, Maastricht (2023)</li> <li>■ ACEDE, Alicante (2023)</li> </ul>


#### 4. STUDY 1

Chistov, V., Aramburu, N., Fabra Florit, M. E., Peña-Legazkue, I., & Weritz, P. (2023).

Sustainability orientation and firm growth as ventures mature. *Business Strategy and the Environment*, 1–18. <https://doi.org/10.1002/bse.3418>

## RESEARCH ARTICLE

## Sustainability orientation and firm growth as ventures mature

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Number: PID2020-114658RB-I00; Aristos  
Campus Mundus**Abstract**

This article revisits the dilemma between sustainability orientation and a firm's growth along the stages of the entrepreneurial process. We draw upon the recent research on sustainable entrepreneurship to determine whether entrepreneurial ventures can pursue sustainability objectives and still grow in terms of turnover and employment. Based on the data of 2 370 firms, we conclude that the relationship between sustainability orientation and a venture's growth is not straightforward. The results show that the stage of the entrepreneurship life cycle matters and that only the introduction of sustainability objectives in the mature stage of the entrepreneurial process (rather than during the early stage) significantly increases the likelihood of such ventures growing. We also find empirical evidence against combining environmental and social dimensions under one umbrella of sustainability, as each of these dimensions demonstrated distinctive behavior in our models. While our results show the importance of innovation for the firm's growth, it is not evident that it exerts any significant moderation effect on the relationship between sustainability orientation and a venture's growth. These findings provide insightful evidence for policymakers about the intrinsic difficulty of reconciling sustainability and economic objectives at the early stages of the process of entrepreneurship and also about the need to differentiate the multiple meanings and forms of sustainability orientation.

**KEYWORDS**

early stage, environmental orientation, growth, innovation, life cycle, mature stage, social orientation, sustainability orientation, sustainable entrepreneurship

**1 | INTRODUCTION**

Our society is currently undergoing a period of sustainability transition that entails significant improvements and balanced integration of economic performance, environmental resilience, and social justice (del Río et al., 2021; Geissdoerfer et al., 2016). Recent evidence suggests that while sustainability issues present challenges to our society, they also provide new business opportunities that can be explored

and exploited by entrepreneurs through innovative business models, products, and services (Adomako et al., 2019; Belz & Binder, 2015). At the beginning of the current century, this idea gave rise to a new research stream on sustainable entrepreneurship. One of the tenets of this field is that entrepreneurship can be seen as a vehicle of change to simultaneously pursue economic, environmental, and social goals (i.e., the so-called triple bottom line) (Belz & Binder, 2015; Lüdeke-Freund, 2020; Schaltegger & Wagner, 2011).

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Being competitive in the marketplace and impactful to society is not an easily achievable dual mission, especially for entrepreneurs (Amankwah-Amoah & Syllias, 2020; Truong & Nagy, 2021). Sustainable entrepreneurs often face the challenge of double externality (Horbach et al., 2012; Mothe et al., 2018; Rennings, 2000) and struggle to capture and appropriate the value from the goods and services they provide. They also carry the burden of the *liability of smallness*, the *liability of newness* in the marketplace (Adomako et al., 2019; Stinchcombe, 2000), and confront multiple institutional obstacles (Amorós et al., 2019; Bernal et al., 2022; Danso et al., 2019; Esposito et al., 2022). As a result, adopting a sustainability orientation in entrepreneurial ventures is considered costly, risky, and taxing on the ability of the firm to survive in the market, reach profitability, and grow (Fernández-López et al., 2022). Therefore, entrepreneurs often hesitate to pursue further social or environmental objectives beyond commercial goals at early stages. This heightened uncertainty prolongs the existence of market and institutional failures and slows the sustainability transition toward a better world (Hoogendoorn et al., 2019; Torugsa et al., 2012).

This study builds on previous research and investigates the relationship between the sustainability orientation (i.e., the pursuit of social or environmental goals beyond commercial objectives) of small entrepreneurial firms and their pattern of growth (Gupta et al., 2013; Klapper et al., 2021). Complementing other recent studies (Danso et al., 2022; Demirel & Danisman, 2019; Fernandes et al., 2021; Lartey et al., 2020), we explore this relationship at different stages of the entrepreneurial process (i.e., early and mature stages), evaluate different growth patterns (i.e., employment and turnover growth and past and expected growth), and differentiate among different types of sustainability orientation (environmental versus social). We also analyze the moderating role of innovation in this relationship since it is considered one of the main determinants of a firm's sustainable and long-term growth (Yu & Yan, 2021).

The purpose of our investigation is to provide a more fine-grained understanding of the relationship between sustainability orientation and firm growth. We expect to contribute to the field of sustainable entrepreneurship in three ways. *First*, we add to previous research on the pursuit of dual sustainability and business growth objectives (i.e., which relies broadly on evidence from large firms) by providing new insights from smaller entrepreneurial firms. Unlike other studies, we analyze the issue through the life cycle perspective on entrepreneurship and distinguish between the early stage of the entrepreneurial process and the mature stage. Contesting recent findings that interpret the challenge of addressing both economic and sustainability objectives by business ventures as a “zero-sum” game (Heras-Saizarbitoria et al., 2022; Soto-Acosta et al., 2016), we show that a feasible “win-win” outcome to achieve the dual mission is possible despite the small size of firms. In fact, we show that sustainability orientation increases the likelihood of ventures' growth but only in the mature stage of the entrepreneurial process (i.e., beyond the fifth year from firm inception).

*Second*, despite the recent tendency in the literature on sustainable entrepreneurship and innovation to treat sustainability as a single

and uniform concept that simultaneously encompasses social, environmental, and economic objectives (Belz & Binder, 2015; Lüdeke-Freund, 2020; Muñoz & Cohen, 2018), we depart from this monolithic perspective and analyze the relationship of different dimensions of sustainability on the growth of the entrepreneurial firms separately. In line with Meek et al. (2010), we find empirical evidence against combining environmental, social, and economic aspects under one umbrella of sustainability, as each of these dimensions demonstrated distinctive behavior in our models. Therefore, we argue that the lack of such distinction in previous research can help explain the diverging and inconclusive results on the relationship between sustainability orientation and the business growth of entrepreneurial ventures (Hockerts & Wüstenhagen, 2010).

Finally, we shed light on the role of innovation (i.e., delivering new products and services to the marketplace) in the growth of entrepreneurial firms. Similar to Demirel and Danisman (2019), our results did not indicate that innovation activities necessarily moderate the relationship between sustainability orientation (both environmental and social) and a firm's growth. As suggested by Nie et al. (2022), both sustainable objectives and innovation activities require resources that entrepreneurial firms simply do not possess due to their size (*liability of smallness*) and time in the market (*liability of newness*). Therefore, the dual goal of being sustainable and innovative may require the redirection of resources from the core business activities, thus jeopardizing the potential for growth. Nevertheless, in our study, innovation proved to increase the likelihood of a firm's growth at mature stages of the entrepreneurial process but not in the early stages. These results suggest that the impact of innovation in small firms varies, again, according to the stage of the entrepreneurial process.

In the next section, we present the theoretical background of this research deepening into the sustainability orientation and the growth of entrepreneurial ventures. The third section describes the data and methodology applied in our empirical tests. The fourth and fifth sections summarize the results and discuss the findings. Finally, we review the limitations and implications of our study and propose avenues for future research.

## 2 | THEORETICAL BACKGROUND

### 2.1 | Sustainability orientation and growth in entrepreneurial ventures

Growth is one of the crucial indicators of a firm's business performance and success in the market (Gupta et al., 2013; Klapper et al., 2021). Consequently, the determinants and models of a firm's growth are considered the cornerstones of most economic and management theories (Coad & Hözl, 2012). In the entrepreneurship literature, the study of business growth has a long history, dating back to the early 1980s (Davidsson et al., 2006). Research suggests that venture growth is a complex phenomenon that can be measured in a variety of ways (i.e., the growth in sales, turnover, number of employees, or assets) and that it is impacted by a wide range of economic, social,

and cultural factors (Audretsch et al., 2014; Gupta et al., 2013). The question of a firm's growth is particularly sensitive for sustainability-oriented ventures that intend to simultaneously achieve environmental, social, and economic objectives (the so-called triple bottom line) (Belz & Binder, 2015; Lüdeke-Freund, 2020; Schaltegger & Wagner, 2011). For entrepreneurs, growth represents not only their ability to survive in the market but also a means to expand their reach and enable further sustainable impact (Acebo et al., 2021; Demirel & Danisman, 2019). Alternatively, the lack of growth can lead to stagnation, reduced market share, and diminished resources for innovation and positive societal impact (Brush et al., 2009).

Balancing the often-competing demands of economic performance, environmental sustainability, and social responsibility is not an easy task (Hoogendoorn et al., 2019). *First*, sustainable business practices may increase operational costs, which can limit a company's economic profitability in the short term (Wilkinson et al., 2001). *Second*, sustainability objectives usually require the redirection of scarce resources (i.e., time, capital, and human resources) from the core activities, thus jeopardizing venture growth and the firm's survival (Bassetti et al., 2021; Fernandes et al., 2021). *Third*, sustainable entrepreneurs often face the challenge of double externality, which refers to the difficulty of capturing and appropriating the value from the provided goods and services due to their public rather than personal nature (Horbach et al., 2012; Mothe et al., 2018; Rennings, 2000). *Fourth*, they also carry the burden of the *liability of smallness*, the *liability of newness* in the marketplace (Adomako et al., 2019; Stinchcombe, 2000), as well as face numerous institutional obstacles, such as governmental and stakeholder pressure, lack of proper financing schemes, cultural barriers, and bureaucratic inertia, among others (Amorós et al., 2019; Bernal et al., 2022; Danso et al., 2019; Esposito et al., 2022). Finally, the rise of degrowth theories, which question the feasibility of unlimited economic growth in a finite world, may discourage entrepreneurs from pursuing growth and scalability (Edwards, 2021; Kallis, 2011).

Challenging the traditional view that environmental and social considerations are at odds with economic success, recent studies suggest that sustainability orientation can actually enhance the growth, profitability, and general competitiveness of entrepreneurial ventures (Belz & Binder, 2015; Lüdeke-Freund, 2020; Schaltegger & Wagner, 2011). Sustainability orientation may entail the integration of sustainability-related values into the corporate culture, a deliberate pursuit of sustainability goals (i.e., environmental, social, and economic), and the introduction of changes into the production and delivery of goods and services (Khizar et al., 2021; Kuckertz & Wagner, 2010). As a result, entrepreneurial ventures develop crucial capabilities such as stakeholder integration, market sensing, and organizational learning, which are essential for long-term success (Grewatsch & Kleindienst, 2017). Furthermore, by adopting sustainable practices, they can develop or acquire valuable and hard-to-imitate resources, which can foster a long-term competitive advantage (Lei et al., 2019). Additionally, a sustainability orientation can enhance a new venture's reputation and legitimacy, leading to an increase in market share and revenue (Truong & Nagy, 2021). These benefits

make a sustainability orientation a key driver for entrepreneurial ventures looking to grow and establish a long-term competitive advantage.

Despite the theoretically deduced potential benefits of sustainability orientation for the venture's growth, there exists a significant lack of empirical studies that test this relationship. The existing evidence shows, on the one hand, a win-win stance by which sustainability orientation can be reconciled with business performance and growth (Soto-Acosta et al., 2016) and, on the other hand, a zero-sum game perspective whereby they are the "two ends of a continuum" (Linder et al., 2014; Stevens et al., 2015), meaning that sustainability objectives can hurt performance indicators of the firm (López et al., 2007). Some authors suggest that sustainability orientation in entrepreneurial ventures can persist only if it does not conflict with their business interests (Kautonen et al., 2020). Alternatively, other scholars claim that searching for this connection is futile and should be abandoned (Margolis & Walsh, 2001). This inconsistency in findings indicates that there may be contextual factors that moderate the relationship between sustainability orientation and venture growth that have not been fully explored in the literature.

## 2.2 | Sustainable entrepreneurship and growth as ventures mature

A notable limitation of the existing literature on sustainable entrepreneurship and growth is the failure to consider a firm's life cycle perspective (Santa-Maria et al., 2022). A number of recent studies propose that the relationship between sustainability orientation and business growth may fluctuate depending on the stage of the entrepreneurial process (Di Vaio et al., 2022; Kuckertz & Wagner, 2010).

In the early stages, entrepreneurial ventures might struggle with the development of proper business models that could simultaneously pursue the triple-bottom line (Kanda et al., 2021). A strong sustainability orientation may also require significant investments of resources (i.e., time, money, and personnel), which young businesses may simply not have, forcing them to divert resources from other critical areas of the business, such as product development, marketing, and customer acquisition (Bassetti et al., 2021; Fernandes et al., 2021). However, other studies suggest that sustainability-oriented ventures at the early stage of their development are more likely to identify market opportunities, build customer loyalty, and create a strong corporate culture (Atif et al., 2022; Kiefer et al., 2019; St-Jean & Labelle, 2018). As a result, the existing empirical evidence provides mixed signals on the issue. According to Renko (2013), sustainability orientation negatively impacts the likelihood of the young venture's survival in the first 4 years of its existence. Paradoxically, Hörisch (2018) discovered that entrepreneurial ventures at earlier stages tend to be more environmentally oriented. However, this changes with time since the experience in the market inevitably present them with the dilemma of whether to contribute to the public good (as initially intended) or focus on individual and business goals (Santos, 2012).

Uhrenholt et al. (2022) explain that the simultaneous achievement of sustainability and business objectives may result from the accumulation of experience, knowledge, and capabilities that happens in the more advanced stages of a firm's development. As a result, mature, sustainable ventures are likely to have more resilient business models, as they are less dependent on a single product or service and can adapt to changes in market conditions (Howard et al., 2022; Santa-Maria et al., 2022). They tend to be more agile and have a better understanding of the social and environmental impact of their activities. This learning allows them to anticipate and respond to changes in customer preferences, regulations, and other factors that affect their business (Gharai et al., 2021). In addition, as ventures grow and expand, they may also have a greater ability to negotiate better prices with suppliers and reduce costs (Elsayed & Paton, 2009; Strebel & Posch, 2004), as well as influence the market and shape the conversation around sustainability (Leipold et al., 2022). They may be able to leverage their reputation and customer base to push for more sustainable practices in the industry (Orlitzky et al., 2003). This can help to create a more sustainable marketplace and generate additional growth opportunities for the firm. Consequently, in the early stages of business development, entrepreneurs may delay the pursuit of sustainability objectives until they accomplish the goal of reaching profitability (i.e., once they surmount the so-called *liability of smallness* and *newness*).

We extend an understanding of the matter by analyzing how sustainability orientation (both environmental and social) affects the firm's growth depending on the stage of its life cycle. In line with Renko (2013) and Uhrenholt et al. (2022), we expect the young firms to face a zero-sum game (i.e., a trade-off between sustainability and business goals) as they learn how to be competitive in the marketplace before impacting society. Once new firms acquire distinctive competencies and the ability to survive and grow in the market, they reach an improved position to achieve a "win-win" stage (by reconciling sustainability and profit objectives). In other words, entrepreneurial businesses are more likely to succeed in reconciling sustainability orientation with business growth as they mature in their respective industry sectors and locations. Hence, we propose the following hypothesis:

**H1a.** Sustainability orientation increases the likelihood of venture growth but only at a mature stage of a firm's life cycle.

### 2.3 | Environmental versus social orientation

The traditionally accepted metaphor of the triple bottom line implies that sustainable entrepreneurs simultaneously pursue social, environmental, and economic objectives (Elkington, 1998). Therefore, recent literature examines sustainability as a uniform and monolithic concept that encompasses all three goals (Belz & Binder, 2015; Klewitz & Hansen, 2014). The common justification for such generalization is that social and environmental entrepreneurs identify and seize

opportunities that arise from major societal challenges, and often those goals are complementary; hence, they share common challenges and opportunities (Schaltegger & Wagner, 2011).

Nevertheless, historically, these concepts have been examined separately (Thananusak, 2019). Furthermore, there exists some evidence that environmentally oriented ventures might be better positioned to achieve commercial success than social ventures. One reason is that green ventures often address a very specific need in the market (i.e., sustainable agriculture and plastic recycling) (Souto & Rodriguez, 2015). This allows a more straightforward estimation of the potential environmental impact and financial returns and makes such projects much more "understandable" for impact investors and venture capitalists (Tenner & Hörisch, 2021). However, due to the breadth and complexity of goals, social ventures may struggle to demonstrate the measurable social and financial impact of their activities (Praszkiar & Nowak, 2011) and therefore secure the necessary private or public funding (Weerawardena & Mort, 2006). Another reason is that green ventures tend to benefit from favorable government policies and regulations (i.e., subsidies or tax incentives) (Jovell-Llopis & Segarra-Blasco, 2018). Indeed, the environmental goals that relate to the efficient use of materials, energy, and other resources have a simultaneous positive effect on both environmental and economic performance (Carrillo-Hermosilla et al., 2009). Consequently, environmental orientation has a direct and "rapid" effect on the costs and profitability of such firms (Nguyen et al., 2020). In contrast, social ventures are deeply rooted in the non-profit and public sectors, where the creation of social benefits prevails over other business objectives (Hoogendoorn et al., 2019). As a result, such firms often target marginalized communities and low-income populations that may not have the purchasing power to support the ventures' products or services (Alvord et al., 2004). This may directly affect their economic bottom line and their ability to grow in terms of turnover (Costanzo et al., 2014).

Finally, some evidence also suggests that environmental orientation may have a positive effect on a venture's growth, particularly at more mature stages of a firm's development, since it often requires a learning process, the development of specialized capabilities and technical knowledge to decrease the firm's environmental impact (Sáez-Martínez et al., 2016). Such capabilities take time to develop but in the long run provide firms with a distinct competitive advantage by enabling them to create innovative and environmentally sustainable products, meet regulatory requirements, and reduce energy consumption and waste (De Marchi et al., 2013; Kiefer et al., 2019; Knoppen & Knight, 2022). The shift towards a more mature stage with an environmental orientation can lead to a significant increase in sales, lower costs, and, therefore, revenue growth (Fernández-López et al., 2022). In contrast, due to the inherent characteristics, social firms tend to have less ambition to grow than most companies (Bacq et al., 2013). Social-oriented firms face pressure from charity programs and stakeholders who often prioritize the accomplishment of a measurable social impact over maximizing financial returns (Ramirez & Ramirez, 2013). Consequently, most social organizations rely heavily on public funding to remain in business. In other words, the ambition

to grow weakens as maximizing economic goals is no longer the main target of socially oriented firms (Ashta, 2020) regardless of the stage of the life course of the firm. Therefore, we expect that:

**H1b.** Environmental orientation and a venture's growth are positively associated at a mature stage, but this relationship does not hold between social orientation and growth.

## 2.4 | Innovation, sustainability, and growth as ventures mature

Entrepreneurs are widely regarded as innovators since they capitalize on market failures and offer novel solutions to their customers (Wang, 2022). Innovation has long been considered a key driver of a firm's growth (Audretsch et al., 2014; Gupta et al., 2013). Today, it is also seen as a critical element in addressing pressing social and environmental challenges of our time and driving sustainability transition (Arekrans et al., 2022; Klewitz & Hansen, 2014; Schaltegger & Wagner, 2011). Despite the perceived straightforward relationship between sustainability orientation, innovation, and growth, entrepreneurs struggle to navigate those competing priorities effectively. Undoubtedly, further research is needed to understand these complex dynamics (Demirel & Danisman, 2019; Klewitz & Hansen, 2014).

Studies show that innovation in sustainability-oriented ventures allows them to differentiate themselves from competitors, improve their cost structures, enhance their reputations with consumers and other stakeholders, and secure their competitive advantage in the long run (Allal-Chérif et al., 2023; Aragón-Correa & Sharma, 2003; Hart, 1997; Weng et al., 2015). Despite resource constraints and the lack of formalized planning, entrepreneurial firms often possess unique characteristics to develop radical innovations and compete in niche markets (i.e., the market of sustainable products) (Arekrans et al., 2022; Schaltegger & Wagner, 2011). Thus, innovation is an essential ingredient to overcome the tensions that inevitably arise when companies aim to reconcile environmental, social, and financial goals (Matzembacher et al., 2020; Souto, 2022). The existing empirical evidence supports this notion and indicates that innovation has a positive moderation and mediation effect on business growth when firms pursue environmental objectives (Ben Amara & Chen, 2020; Wang et al., 2021) as well as social objectives (Guerrero-Villegas et al., 2018; Hull & Rothenberg, 2008; Wang, 2022). Therefore, we anticipate that in our study, innovation positively affects the relationship between environmental and social orientation and ventures' growth.

However, prior research also suggests that the firm's age and the stage in its entrepreneurial process might influence the venture's innovation and sustainability orientation (Leoncini et al., 2019; Yin et al., 2022). It is believed that older firms might already have their entrepreneurial activities and strategies in place and can refocus from survival in the market to expansion and positive contribution to society (Anderson & Eshima, 2013; Di Vaio et al., 2022; Kilenthong et al., 2016). More mature firms also possess the essential prior

knowledge and experience (both positive and negative) to develop innovations and a broader legitimacy to establish critical external partnerships to access the expertise and resources needed for R&D activities (Di Vaio et al., 2022; Withers et al., 2011). Thus, we posit the following hypotheses:

**H2a.** Innovation activities positively moderate the relationship between environmental orientation and a venture's growth at a mature stage of a firm's life cycle.

**H2b.** Innovation activities positively moderate the relationship between social orientation and venture growth at the mature stage of a firm's life cycle.

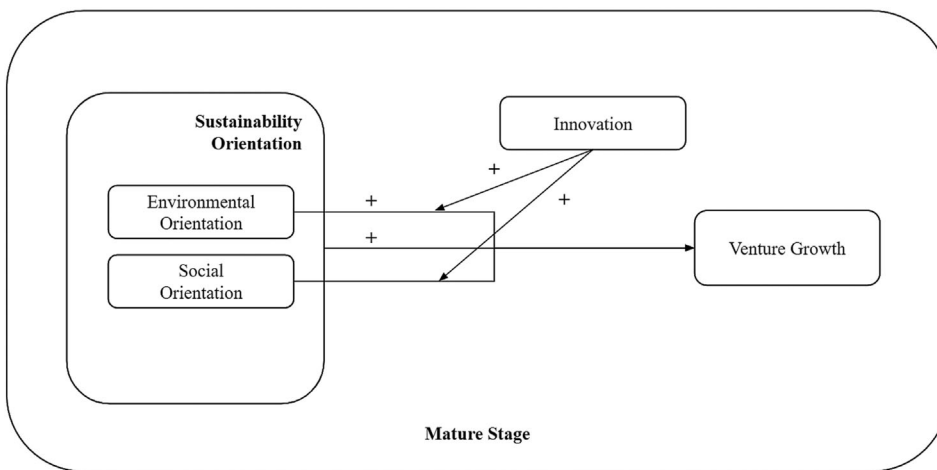
To conclude Section 2, we summarize the hypotheses for our study in Figure 1.

## 3 | METHODOLOGY

### 3.1 | Sample data

The Global Entrepreneurship Monitor (i.e., GEM) is one of the few international projects designed to study the process of entrepreneurship, and it is particularly helpful to analyze how entrepreneurial ventures evolve during and after the critical early stage of new ventures (Pinzón et al., 2021). Interestingly, the GEM data have been previously used to investigate the environmental orientation of new ventures (Hörisch et al., 2019), the determinants of social entrepreneurship (Canestrino et al., 2020; Leković et al., 2021), and the performance of green entrepreneurship (Yin et al., 2022). To the best of our knowledge, the 2019–2020 GEM dataset from Spain is the last dataset of the GEM consortium (i.e., before the COVID-19 pandemic shock) that provides information on whether a firm has a “sustainability orientation” and on the pursued type of “sustainability orientation” (i.e., “environmental-oriented” or “social-oriented” sustainability). This GEM dataset also allows the categorization between “early” or “mature” stages of business ventures by considering their year of firm inception. Most importantly, the dataset provides unique information regarding the recent growth of these firms (i.e., turnover and employment growth during the last 3 years). For all the abovementioned reasons, we consider the GEM-Spain 2019 dataset a suitable source to conduct our empirical work and to test our study propositions.

Since we investigate the relationship between sustainability orientation, innovation, and venture growth from a life cycle perspective, the unit of analysis of our sample is an entrepreneurial firm that remains active either in an “early stage” or a “mature stage” of the entrepreneurial process. In particular, we define a commonly accepted threshold of 5 years from inception to classify companies that are operating in an “early stage” (i.e., up to 5 years of existence) versus a “mature stage” of the firm life cycle (i.e., more than 5 years of existence). This pragmatical criterion has been widely used in the management and economics literature (Muda et al., 2020; Peña, 2004), as



**FIGURE 1** Summary of hypotheses. Source: Authors' elaboration.

well as in reports from numerous international organizations like the OECD and European Commission. Our sample consists of 2254 entrepreneurial firms, of which about one-third are in the “early stage” category and the rest in the “mature stage” category.

## 3.2 | Measurement of variables

### 3.2.1 | Dependent variables

The dependent variable of our study is “past growth.” We are aware that there is no single indicator to measure firm growth. Rather, business expansion can be measured in multiple ways (i.e., by assessing the evolution of different indicators such as the growth of sales revenues, employment, equity, and profits). The GEM project asks the interviewees about the most recent expansion experienced by their venture in terms of growth in employment and turnover (i.e., interestingly, the latter is available only in the case of the dataset of GEM-Spain). The measurement of firm growth is more accurate if, instead of using a separate indicator of growth for every single variable, an alternative indicator of *simultaneous* growth of two variables is applied (Fernández-López et al., 2022). In this study, we consider that a firm grows when both employment growth and turnover growth occur together. Thus, we create a dichotomic variable, *Past Growth*, to describe whether a venture grew simultaneously in these two growth indicators during the last 3 years before the survey was carried out. This dependent variable takes the value of one (1) if a firm experienced both turnover and employment growth over the previous 3 years and zero (0) otherwise.

### 3.2.2 | Independent variables

The primary explanatory variable represents the “sustainability orientation” of entrepreneurial ventures, which allows us to test whether sustainability objectives complement or conflict with business growth in both the “early” and “mature” stages of the entrepreneurial

process. Sustainability orientation is a notion commonly applied to represent the firm's stance to conduct operations in a sustainable manner (Adomako et al., 2019; Haldar, 2019). Due to the differences in the definition of sustainability orientation, there also exist differences in how researchers approach its measurement Hörisch (2018). On this regard, Calic and Mosakowski (2016) and Testa et al. (2020) proposed a simplified measurement, which considered a venture to have a sustainable orientation if it somehow benefited people or the natural environment. In line with this approach, the GEM 2019 survey asks entrepreneurs if they aim to solve environmental or social problems in addition to pursuing an economic goal. Following the literature and relying on the data available from GEM, we create a variable, *Sustainability Orientation*, that takes the value of one (1) if the organization aims to achieve sustainability objectives and the value of (0) if the firm focuses *exclusively* on economic objectives.

To distinguish the two types of *sustainability orientation* examined in our study (i.e., environmental-oriented and social-oriented sustainability), we rely on the limited GEM data available to explore this issue. In the survey, entrepreneurs are asked if they pursue environmental or social goals in addition to economic objectives. Thus, we create a variable *Environmental goal* that takes the value of one (1) if the venture is driven by environmental goals beyond an economic goal and zero (0) if it aims to achieve an economic return *exclusively*. Likewise, the variable *Social goal* takes the value of one (1) if the venture pursues a social purpose beyond an economic goal and zero (0) when it seeks an economic return *exclusively*.

### 3.2.3 | Moderator

The resources needed to innovate and reach sustainable goals often conflict with the means needed to satisfy profit goals (Nie et al., 2022). To investigate these counterbalancing forces, we create a variable, *Innovation*, to understand how the “innovative orientation” of entrepreneurial ventures influences the relationship between “sustainability orientation” and “business growth.” The respondents are asked whether their business delivers products and services that are

new for either local, national, or foreign customers. Indeed, the GEM dataset gathers limited information about the newness and innovative behavior as the data neither does differentiate the several levels of innovation (i.e., incremental or radical innovation) nor the type of innovation (i.e., product innovation, process innovation, and managerial innovation). Instead, the GEM survey asks, in a simplified way, whether the product/service is new in the local, national, or global market. Thus, this variable takes the value of one (1) when a venture delivers a product or service that is new in the local, national, or world market and zero (0) otherwise. For the purpose of this study, a dichotomic variable suffices to capture any effort made by entrepreneurs to be innovative (i.e., we note here that innovation per se is not the main focus of our investigation). Similar proxies have been used in previous research to reflect the innovative orientation of entrepreneurial firms (Criado-Gomis et al., 2018; Renko, 2013).

### 3.2.4 | Control variables

We include multiple control variables that are associated with ventures' growth. At an individual level, we added both demographic and human capital variables to control for the personal profile of entrepreneurs (Hechavarría & Welter, 2015; Muñoz-Bullón et al., 2015). The demographic variables include *Gender* (i.e., the variable takes value 1 for Females and 0 otherwise) and *Age* (i.e., years of the respondent). The human capital variables represent *College Education* (with a value of 1 if the business owner completed the college degree and 0 otherwise), *Entrepreneurship Training* (with a value of 1 if a business owner participated in any kind of entrepreneurship training programs and 0 otherwise), *Entrepreneurship Experience* (with value 1 if a business owner sold, shut down, or quit the business in the past 12 months and 0 otherwise), *Investment Experience* (with value 1 if a business owner provided funds for a new business in the past 3 years and 0 otherwise), or *Entrepreneurial Network* (with value 1 if a respondent knows personally other entrepreneurs who started their own business and 0 otherwise). At the firm level, we added variables describing the size of the firms measured by the number of employees (*Firm\_size*), the industry sector in which they operate (*Manufacturing\_Sector*, with value 1 if the firm operates in the manufacturing sector and 0 otherwise), and their international orientation (*Export-driven*, with value 1 if the firm operates in global markets and 0 otherwise). Several studies have found that such organizational variables affect the growth of entrepreneurial ventures (González-Pernía & Peña-Legazkue, 2015; Renko, 2013).

### 3.2.5 | Robustness test

Applying the theory of planned behavior (TPB), the expectation of "future growth" is determined by the opportunities and potential for business expansion that entrepreneurs perceive at the present moment (Lortie & Castogiovanni, 2015). To test our models for robustness and consistency, we introduce an additional dichotomic

variable *Future Growth* that captures the potential growth of a venture by considering the expectation of the owner to create new jobs in the next 5 years from the date of the survey. Unfortunately, GEM does not provide information on the expected growth in terms of turnover, but it does in terms of the generation of new jobs. In the absence of other proxies, the expected growth in employment reflects an extended view of the life cycle of a firm and also its disposition to hire more people as the company expands. Thus, we create a dichotomic variable, *Future Growth*, to describe whether a firm will pursue (or not) organic growth through the company's own resources. This variable takes the value of one (1) if the entrepreneur expects to create new jobs in the next 5 years and zero (0) otherwise.

## 3.3 | Statistical method

A binominal logistic regression method is used to test our hypotheses, which estimates the probability of an event happening. In our study, this event represents our dichotomic dependent variable *Past Growth* (i.e., the turnover and employment simultaneous growth experienced by a firm in the last 3 years). The predicted proportion follows the logistic model of  $\ln P/(1 - P_i) = \beta X_i$ , where  $P_i$  is the probability of taking the value one (1) when the venture grows and (0) otherwise (Hosmer & Lemeshow, 2004).

The logarithmic odds of this event are held to be linearly affected by a vector of covariates  $X_i$ , with coefficient vector  $\beta$ . The covariates include the main independent variables (i.e., *Sustainability orientation*, *Environmental goal*, and *Social goal*), the moderating variable (*Innovation*), and the rest of the control variables. Maximum likelihood estimations are used to calculate the logistic coefficients, which denote changes in the log-odds of the dependent variable *Past Growth* (Greene, 2003). We assess the goodness of fit of the models using Nagelkerke's *R*-square indicator. To analyze the structural validity of our models, we perform robustness checks using the dependent variable *Future Growth*.

## 4 | RESULTS

We examine the characteristics of the data and the variables used in our models before running our models. The descriptive statistics and correlation coefficients of the variables are included in Table 1. The companies in our sample, on average, do not exceed three employees in size, only 7% are in the manufacturing sector, and approximately 1 out of 4 firms sell their products and services abroad. This might indicate that most businesses are small, operate in the service sector, and trade mainly in the local market. Almost one-third of business ventures are less than 5 years old (i.e., "early stage"), near to 40% have recently grown simultaneously in employment and turnover, and approximately 1 out of 10 firms pursue a "sustainability-oriented" mission (see Descriptive statistics and correlation matrix in Table 1). A positive correlation exists between "early-stage" firms and growth, but a negative correlation exists between "early-stage" firms and



**TABLE 1** Descriptive statistics and correlation matrix.

	Mean	1	2	3	4	5	6	7	8
1	0.31								
2	0.69	-1.000**							
3	0.12	-.087**	.087**						
4	0.08	-.076**	.076**	.818**					
5	0.04	-.038	.038	.524**	-.061**				
6	0.88	.099**	-.099**	-.842**	-.689**	-.441**			
7	0.41	.295**	-.295**	.041	.054*	-.010	-.016		
8	0.30	.173**	-.173**	.042	.056*	-.011	-.010	.213**	
9	0.24	.087**	-.087**	.047*	.037	.025	-.037	.108**	.175**
10	0.47	.030	-.030	-.013	-.021	.009	-.014	-.049*	-.043
11	47.78	-.320**	.320**	.009	.005	.007	-.037	-.184**	-.221**
12	2397.24	-.309**	.309**	.011	.008	.008	-.039	-.181**	-.224**
13	0.25	.059**	-.059**	.043	-.014	.095**	-.006	.078**	.064**
14	0.51	.020	-.020	.099**	.108**	.013	-.083**	.097**	.060*
15	0.02	-.035	.035	.012	.032	-.027	.004	-.009	.003
16	0.05	-.073**	.073**	-.005	-.027	.031	.001	-.003	.000
17	0.3817	-.010	.010	-.017	-.030	.015	.042*	.044*	.063**
18	0.24	.021	-.021	-.008	-.009	-.001	.001	.089**	.101**
19	0.07	-.031	.031	-.030	-.006	-.044*	.047*	.000	.043
20	2.31	-.005	.005	.074**	.080**	.010	-.075**	.092**	.171**

Note: N = 2254 observations.

\* $p < .05$ . \*\* $p < .01$  pairwise correlations.

**TABLE 1** (Continued)

	9	10	11	12	13	14	15	16	17	18	19
1											
2											
3											
4											
5											
6											
7											
8											
9											

TABLE 1 (Continued)

	9	10	11	12	13	14	15	16	17	18	19
10	-.029										
11	-.116**	-.054**									
12	-.116**	-.064**	.991**								
13	.079**	.005	-.055**	-.061**							
14	.050*	-.006	-.113**	-.113**	.065**						
15	.023	-.038	.047*	.048*	.006	.017					
16	-.009	-.009	.044*	.053*	.009	.008	.066**				
17	.038	-.059**	-.063**	-.061**	.035	.051*	.079**	.089**			
18	.108**	-.016	-.031	-.034	.056**	.038	-.004	.001	.050*		
19	.052*	-.043*	.001	.005	-.064**	-.005	.015	-.019	-.022	-.008	
20	.052*	-.034	-.003	-.002	.017	.050*	.051*	.040	.057**	.124**	.066**

Note: N = 2254 observations.  
\*p < .05. \*\*p < .01 pairwise correlations.

sustainability orientation. In contrast, there is a negative correlation between “mature-stage” firms and growth but a positive correlation between “mature-stage” firms and sustainability orientation. In view of this preliminary examination, the initial outcomes imply the existence of different goal priorities depending upon the stage of the business lifecycle in which a firm stands.

Overall, the estimated coefficients of the correlation analysis of our representative sample show no risk for multicollinearity among the explanatory variables. We examined the variance inflation factors, and they fell within an acceptable range (i.e., under 5.0), indicating that multicollinearity is not an issue in interpreting our results.

Table 2 reports the effect of sustainability orientation on firm growth for both “early-stage” and “mature-stage” firms. The results of Model 1 indicate a positive and significant effect of the variable *Sustainability Orientation* on the growth of firms at a “mature stage” (i.e.,  $\beta = .384, p < .05$ ). This outcome suggests that entrepreneurial ventures, once established in the marketplace (i.e., when they face a “mature stage”), are better able to reconcile the dual objective of sustainability and firm growth. These results confirm our Hypothesis 1a.

Next, we split the *Sustainability Orientation* variable into the achievement of two distinct types of sustainable goals: *environmental* goals and *social* goals. While pursuing an environmental goal increases the likelihood of experiencing firm growth for “mature-stage” firms (i.e.,  $\beta = .642, p < .05$ ), pursuing a social goal has the opposite effect (i.e., but this effect is not statistically significant). Therefore, we find broad empirical support for Hypothesis 1b.

The results from Models 3 and 4 (see Table 3) (in line with the results from Models 1 and 2) show that *environmental goals* are positively associated with firm growth (i.e.,  $\beta = .538, p < .05$ ) only in a “mature stage.” Once again, *social goals* do not show any statistically significant results. The variable *Innovation* has a positive and significant effect only on the growth of mature firms both in Model 3 ( $\beta = .324, p < .05$ ) and Model 4 (i.e.,  $\beta = .412, p < .05$ ). No significant result was found for the moderating effect of the variable *Innovation* on the relationship between environmental and social orientation and past growth. Thus, Hypotheses 2a and 2b cannot be confirmed.

We run robustness tests to confirm the effect of our main variables (i.e., sustainability orientation and innovation) on the “expected” growth trend (i.e., rather than “past” growth tendency) and, therefore, to understand this phenomenon from a broader life cycle perspective. For that purpose, we use the variable *Future Growth*, or the expectations of growth of the business owners, for the next 5 years (i.e., see Tables 4 and 5). Complementing our previous outcomes, we find a positive and significant relationship between sustainability orientation and “expected” firm growth in the “early stage” (i.e.,  $\beta = .849, p < .05$ ). The same relationship is replicated between the pursuit of *environmental* goals and the “expected” firm’s growth in “early-stage” ventures (i.e.,  $\beta = 1.646, p < .05$ ).

The robustness tests confirm our previous outcomes on the effect of *Innovation*. For instance, the effect of innovation on future growth is positive and significant for both “early-stage” and “mature-stage” firms seeking either an environmental goal (i.e.,  $\beta = .467, p < .05$  and  $\beta = .689, p < .01$ , respectively) or a social

**TABLE 2** Results for sustainability orientation and firm growth.

	Model 1 (past growth)		Model 2 (past growth)	
	Early-stage firms $\beta$	Mature-stage firms $\beta$	Early-stage firms $\beta$	Mature-stage firms $\beta$
Explanatory variables				
Sustainability orientation	.215	.384**	-	-
Environmental goal	-	-	.593	.642**
Social goal	-	-	-.509	-.288
Control variables				
Gender	-.292	-.204	-.295	-.206
Age	-.006	.007	-.011	.010
Age-square	.000	.000	.000	.000
College education	.067	.208	.059	.250*
Entrepreneurship training	.217	.492***	.201	.481***
Entrepreneurship experience	.031	-.201	-.105	-.249
Investment experience	-.160	.404	-.193	.444*
Entrepreneurial network	.044	.111	.070	.114
Export-driven	.099	.495	.090	.499**
Manufacturing_Sector	.079	.111	.063	.104
Firm_size	.063**	.034**	.064**	.034**
Constant	1.708	-.907	1.829	-.985
Nagelkerke's $R^2$	8.5%	6.9%	9%	7.6%
Number of observations	623	1361	623	1361

\* $p < .1$ . \*\* $p < .05$ . \*\*\* $p < .01$ .

goal (i.e.,  $\beta = .541$ ,  $p < .05$  and  $\beta = .783$ ,  $p < .01$ , respectively), indicating the vital role of innovation for the successful growth of any type of company. Interestingly, the moderating effect of *Innovation* is positive and significant for ventures in a “mature stage” aiming at accomplishing *environmental* goals (i.e.,  $\beta = .878$ ,  $p < .1$ ).

The control variables behave as expected. The firm size and the exporting orientation of mall firms are positively related to business expansion, especially in firms at “mature stages” (i.e., see Models 1–4). Regarding the profile of the ventures' owners, we find a positive effect of several human capital variables (i.e., college education, entrepreneurship training, angel investment experience, and entrepreneurial network) on firm growth. However, women entrepreneurs are less likely to experience firm growth, and as owners get older beyond a threshold age, the probability of business expansion declines (i.e., an inverse U-shape curvilinear effect). These results support previous findings on the positive influence of some individual-level and firm-level variables on business growth (Dimov, 2010; Muñoz-Bullón et al., 2015).

In sum, our results underline the importance of the life cycle perspective to capture more accurately the relationship between sustainability orientation and firm growth by looking at different stages of the entrepreneurship process (i.e., early and mature stages), different growth patterns (i.e., employment and turnover growth and past and expected growth), and different types of sustainable orientation

(i.e., the pursuit of environmental versus social goals). By highlighting all the nuances of these blurred notions, our novel findings are expected to provide a more fine-grained understanding of the striving relationship between sustainability orientation and firm growth.

## 5 | DISCUSSION OF FINDINGS

In this study, we investigate the relationship between sustainability orientation and a firm's growth in entrepreneurial ventures at different stages of their life cycle, with a possible moderation effect of innovation. We discuss our findings in the following section.

First, our literature review showed the lack of empirical research that tests the relationship between sustainability orientation and growth in business ventures. Most studies focus on the theoretical benefits of why sustainability orientation should have a positive influence on various aspects of the business. But only a few of them test empirically. Also, the scarce existing evidence is mostly inconclusive and controversial. Compared to similar studies (Danso et al., 2022; Demirel & Danisman, 2019; Fernandes et al., 2021; Lartey et al., 2020), we analyzed this complex relationship at different stages of the entrepreneurial process (i.e., early and mature stages), evaluated different representations of firm's growth (i.e., employment and turnover growth and past and expected growth), differentiated among

**TABLE 3** Results for sustainability orientation, innovation, and firm growth.

	Model 3 ( <i>past growth</i> ) Environmental goal		Model 4 ( <i>past growth</i> ) Social goal	
	Early-stage firms	Mature-stage firms	Early-stage firms	Mature-stage firms
	$\beta$	$\beta$	$\beta$	$\beta$
Explanatory variables				
<i>Sustainability orientation (SO)</i>	.658	.538**	-.952	-.318
<i>Innovation</i>	.116	.324**	.096	.412**
<i>SO</i> × <i>innovation</i>	-.156	.310	1.381	-.268
Control variables				
Gender	-.288*	-.194	-.305*	-.198
Age	-.006	.014	-.018	.008
Age-square	.000	.000	.000	.000
College education	.035	.241	.054	.260*
Entrepreneurship training	.204	.475***	.217	.510***
Entrepreneurship experience	-.071	-.334	.106	-.307
Investment experience	-.170	.437*	-.178	.399
Entrepreneurial network	.064	.116	.058	.105
Export-driven	.073	.484**	.059	.455**
Manufacturing_Sector	.041	.117	.034	.089
Firm_size	.062**	.032**	.063**	.034**
Constant	1.681	-1.177	1.980	-.957
Nagelkerke's $R^2$	8.9%	8.2%	8.9%	7.3%
Number of observations	623	1361	623	1361

\* $p < .1$ . \*\* $p < .05$ . \*\*\* $p < .01$ .

different types of sustainability orientation (environmental versus social), and tested the possible moderation role of innovation. Our results support the methodological concerns expressed by Margolis and Walsh (2001) that the research into the relationship between sustainability orientation and business growth is inconclusive because it lacks common standards to measure the constructs, fails to account for possible moderation and mediation effects of other factors, and uses the data that represents contexts and firms with distinct characteristics and backgrounds. We agree that due to the methodological and conceptual differences, finding a stable and common pattern between sustainability orientation and business growth across all types of firms might be challenging.

Second, the manifest limitation of corporate social responsibility (CSR) and sustainability studies has been their predominant bias toward the context of large corporations (Castka et al., 2004; Leonidou et al., 2017). However, recent studies suggest that small firms also have the potential to generate economic and social value, exploring and exploiting the market failures related to the *Grand Challenges* of the modern world (Cohen & Winn, 2007; Dean & McMullen, 2007). In line with Soto-Acosta et al. (2016), our findings show that accomplishing the dual sustainability-growth objective is feasible but especially challenging for ventures in the early stage of their operations. We must bear in mind that

approximately 1 in 10 ventures' owners in our sample had a sound intention to pursue sustainability objectives, and the rest are *exclusively* profit-oriented commercial firms (i.e., with no sustainability purpose). These results coincide with the previous notion that only a tiny proportion of business ventures pursue sustainability goals (Cohen & Winn, 2007).

A plausible explanation for the lack of sustainability-oriented business ventures is that they struggle to remain profitable in the marketplace, and adding an impactful purpose to the firm can jeopardize its growth. That is, the sustainability orientation in entrepreneurial firms (at least, in the early stage of their life cycle) can be counterproductive, as it brings more complexity to business processes, a redirection of resources (both human and financial) to noncore activities, and requires new capabilities (Klewitz & Hansen, 2014; Rennings, 2000; Stevens et al., 2015). Nevertheless, the *liability of smallness* should not prevent them from being essential actors and drivers of sustainability transition (Drayton, 2002; González-Pernía et al., 2015). While entrepreneurs are often uncertain about the feasibility of pursuing sustainability and commercial objectives simultaneously, in reality, sustainability orientation can go along and even enhance the ability of the firm to remain profitable and stay competitive in the marketplace (Soto-Acosta et al., 2016), but according to our results, this only holds in the long run after firm inception.

TABLE 4 Robustness test for sustainability orientation and expected firm growth.

	Model 5 (future growth)		Model 6 (future growth)	
	Early-stage firms	Mature-stage firms	Early-stage firms	Mature-stage firms
	$\beta$	$\beta$	$\beta$	$\beta$
Explanatory variables				
Sustainability orientation	.849**	.168	-	-
Environment goal	-	-	1.646**	.139
Social goal	-	-	-.812	.236
Control variables				
Gender	-.197	-.271*	-.205	-.271*
Age	-.117	.016	.096	.016
Age-square	-.002**	-.001	-.002*	-.001
College education	.247	.167	.220	.162
Entrepreneurship training	.194	-.045	.162	-.044
Entrepreneurship experience	.166	.530	.101	.536
Investment experience	.345	.156	.262	.152
Entrepreneurial network	.131	.295*	.194	.294
Export-driven	.276	.463**	.243	.463**
Manufacturing_Sector	.840*	.211	.826*	.212
Firm_size	.187***	.053***	.190***	.053***
Constant	-2.488*	-.330	-2.037	-.324
Nagelkerke's R <sup>2</sup>	19.6%	10.2%	21.5%	10.2%
Number of observations	623	1361	623	1361

\* $p < .1$ . \*\* $p < .05$ . \*\*\* $p < .01$ .

Third, an important finding of this study is the confirmation of our initial conjecture that the stage of the life cycle where a firm stands also plays a vital role in understanding the relationship between sustainability orientation (particularly environmental) and a firm's growth. A reconciliation of sustainability and commercial objectives seems to be feasible when ventures accumulate the necessary knowledge and capabilities (Uhrenholt et al., 2022) and when profits allow them to add sustainability purposes, which generally happens as ventures mature. The firm life cycle perspective may also partially explain why the conclusions in the literature on the sustainability orientation and firm's growth relationship have not been consistent.

Fourth, our results also indicate that the undergoing convergence of environmental and social dimensions under one umbrella term of sustainability (Klewitz & Hansen, 2014) and treating them equally may lead to errors in the results and a general understanding of sustainable entrepreneurship and innovation. In our study, environmentally oriented firms were more likely to grow, while social orientation was negatively related to growth. This dynamic follows the previous suggestions that environmental objectives complement better financial goals and can bring tangible returns to the venture in the short term by avoiding fines, decreasing the costs for energy and materials used in production, and waste disposal (York, 2009). However, social orientation is commonly rooted in the non-profit sector and prioritizes public benefit over business objectives in general (Hoogendoorn

et al., 2019). In addition, social issues typically exist in a particular context and require close cooperation with various stakeholders. Consequently, social business models are hard to scale and require a different mindset, more ambition, effort, resources, and time to also bring tangible economic benefits to organizations. Due to the underlying difference in the nature of both concepts, we believe that combining social and environmental orientations under one term of sustainability orientation may lead to confusion and oversimplification of the issues at hand. It also may lead to such possible paradoxes when sustainability-oriented firms prioritize environmental goals over social goals, such as choosing to use renewable energy sources that are more expensive than fossil fuels but may cause displacement of local communities and the drastic rise of prices for basic needs (Martin & Islar, 2021).

Finally, contrary to our expectations, we did not find any significant evidence that innovation has any moderation effect on the sustainability-growth relationship. This also goes against the commonly accepted notion that sustainable entrepreneurs tend to rely more on innovation to find novel solutions to Grand Challenges and new business models that could reconcile sustainability and economic purposes (Dangelico, 2016). The probable explanation may be that the combination of both sustainability and innovation increases the complexity of business processes that require certain established routines and capabilities (Ketata et al., 2015). With an average of three

**TABLE 5** Robustness tests for sustainability orientation, innovation, and expected firm growth.

	Model 7 (future growth) Environmental purpose		Model 8 (future growth) Social purpose	
	Early-stage firms	Mature-stage firms	Early-stage firms	Mature-stage firms
	$\beta$	$\beta$	$\beta$	$\beta$
Explanatory variables				
Sustainability orientation (SO)	1.575**	-.282	-.581	.084
Innovation	.467**	.689***	.541**	.783***
SO $\times$ innovation	.093	.878 *	-1.313	.126
Control variables				
Gender	-.198	-.240	-.219	-.245
Age	.106	.006	.104	.009
Age-square	-.002*	-.001	-.002*	-.001
College education	.115	.190	.131	.182
Entrepreneurship training	.160	-.034	.206	-.054
Entrepreneurship experience	.274	.330	.333	.397
Investment experience	.324	.139	.342	.129
Entrepreneurial network	.194	.273*	.156	.275*
Export-driven	.159	.442**	.148	.432**
Manufacturing_Sector	.717	.217	.615	.226
Firm_size	.185***	.050***	.198***	.051**
Constant	-2.396	-.284	-2.359	-.368
Nagelkerke's R <sup>2</sup>	22.2%	13.3%	20.1%	12.9%
Number of observations	623	1361	623	1361

\* $p < .1$ . \*\* $p < .05$ . \*\*\* $p < .01$ .

employees, the entrepreneurial ventures in our sample seem not to have the organizational capacity to align and simultaneously handle sustainability and innovation processes.

## 6 | LIMITATIONS AND DIRECTIONS FOR FUTURE RESEARCH

Our study has several limitations that can be addressed in future research. First, our results represent a “snapshot” of active entrepreneurial businesses in Spain in 2019. This is a static perspective that does not show their evolution over time. Since the results of our research are incipient about the impact of the stage of the firm's life cycle on the relationship between sustainability orientation and business growth, a longitudinal study (i.e., based on panel data like from the project *Panel Study of Entrepreneurial Dynamics*) may be helpful. The second limitation comes from the context of our sample. According to institutional theory, entrepreneurs face a wide range of obstacles (i.e., financial, administrative, and informational barriers) that might be present in the Spanish context but not in the context of other countries. A particularly interesting question might be to uncover the sustainability-orientation-venture growth dynamic in the context of economic or social crises (i.e., the global COVID-19

pandemic or the new global context due to the war conflict in Ukraine). The third limitation is related to the ways we choose to measure the variables. For instance, evidence suggests that it is possible to measure the strength of sustainability orientation (Santos et al., 2013) as well as the radicalness of innovation (Kiefer et al., 2017). Introducing such distinctions in future research may help to understand better the relationship between sustainability orientation and a firm's growth.

Despite the limitations, this study provides several practical and policy implications. First, it intends to reassure entrepreneurs of their decision to pursue sustainability objectives. We do not claim to have found a definitive answer for the dilemma between sustainability orientation and business growth but wanted to show that, at least in a specific context, those two objectives may coexist and enhance each other. We hope it will encourage entrepreneurs not to give up on their dream “to do good” when the “going gets tough.” Second, entrepreneurs and small businesses are the backbones of any economy, and our study also provides evidence that they have the potential to become a backbone of the sustainability transition. However, due to additional dimensions and complexity of sustainability orientation, such ventures require extra attention, support, and investments, particularly in the early stages of their development, to propose innovative solutions for the *Grand Challenges* of our society and

survive in the market. Policymakers may design programs encouraging entrepreneurs to pursue sustainable goals since achieving this dual mission benefits both business owners and the community. Our results suggest that this outcome is feasible but depends on the maturity of firms and their stage in the entrepreneurial process. Raising awareness and shifting resources to support impactful and competitive sustainability-oriented ventures will facilitate the transition toward a more sustainable society.

## 7 | CONCLUSION

In this study, we analyze the dilemma between sustainability orientation and business growth faced by entrepreneurial ventures and how they handle it across different stages of their life cycle. There is no doubt that the introduction of sustainability objectives is a challenging process for entrepreneurial ventures (Gupta et al., 2013; Stevens et al., 2015), but in light of the new evidence from our study, it becomes clear that with perseverance, the benefits of sustainable products, services, and business models in the context of entrepreneurship may outweigh the expenses and difficulties of their production and delivery to the market. Sustainability orientation creates added value to society on top of the market value of the product or service that entrepreneurs capture through innovative business models (Ndubisi & Nair, 2009; Shepherd & Patzelt, 2011). The novelty of these results, compared to those of earlier research, may indicate that our society is indeed transitioning towards a more sustainable future and that due to stricter government regulations, stakeholder pressure, general awareness about environmental and social issues, and increasing demand from consumers for sustainable products and services, sustainability-driven firms become more profitable and competitive in the market (Ndubisi & Nair, 2009; Shepherd & Patzelt, 2011).

We also encourage future studies on sustainable entrepreneurship and innovation to keep in mind the life cycle perspective on the entrepreneurship process. Conventional wisdom suggests that approximately half of the new ventures shut down sometime during their five initial years. The early stage of a new firm is a critical period where entrepreneurs must discover and develop the ability to be competitive and profitable. Launching and building a profitable business follows a complicated process. Adding to it, the pursuit of a sustainability purpose makes this challenging test a more complex task. Our results show that sustainability and business objectives may not be continuously and simultaneously satisfied together. Although sustainability orientation may drive business growth, this rationale may not hold across all phases of the life course of an organization. Our findings suggest that it seems more feasible to reconcile commercial and at least environmental objectives in the later stages of a firm's life cycle.

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## CONFLICT OF INTEREST STATEMENT

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

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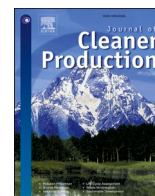
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## 5. STUDY 2

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# Open eco-innovation: A bibliometric review of emerging research

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## ABSTRACT

The growing concern about the environmental future of the Planet urges us to foster eco-innovation research and implementation in companies. Access to external knowledge, R&D collaboration, and open innovation are recognized as essential drivers of eco-innovation. Despite the growing interest, research on the topic is still scarce. The present article strives to clarify the concept of Open Eco-innovation, shows its importance, and maps existing research applying a systematic approach to a literature review, bibliometric and science mapping analysis, using citations from Web of Science and Scopus databases. The results give an overview of academic discussions that led to the topic of Open Eco-innovation, demonstrate a growing interest from the scientific community, and reveal comprehensive bibliometric data concerning leading authors, research groups, affiliations, and most notable publishers and publications. The article also proposes a new conceptual framework for the research on Open Eco-innovation, which represents the main clusters and topics of discussions distributed among macro, meso, and micro-levels of analysis.

## 1. Introduction

Interest in the potential use of Open Innovation (OI) in the process of eco-innovation (EI) is gradually gaining importance in the academic and professional literature (Pereira et al., 2020). This phenomenon is increasingly termed Open Eco-innovation (OEI) (Ghisetti et al., 2015; González-Moreno et al., 2019). It is also referred to as open environmental innovation (Russo Spina and Di Paola, 2020), open (green) innovation (Winston, 2010), sustainable open innovation (SOI) (Bogers et al., 2020), and inter-organizational collaboration (cooperation) in eco-innovation (Melander, 2017; Pereira et al., 2020).

The growing body of theoretical and empirical research shows the ability of OEI to recouple the economic and environmental objectives of organizations and to contribute to sustainable transition of our society (Kiefer et al., 2021; Russo Spina and Di Paola, 2020). OEI, collaboration, and access to external knowledge may help overcome the classic barriers to EI, such as the lack of resources and capabilities (Ben Amara and Chen, 2020; Del Río et al., 2015). It can also contribute to achieving the strategic goals of organizations, including stronger economic performance (Rauter et al., 2019), higher environmental performance (Ben Amara and Chen, 2020) and greater competitive advantage (Wagner, 2009). OEI strategies may also help to reduce R&D costs (Martinez et al.,

2014), achieve better compliance with environmental regulations (Pereira et al., 2020), tap into the embedded potential for innovation by groups of firms (Georg et al., 1992), identify new business opportunities (Ben Amara and Chen, 2020) and reduce the economic risks faced by companies (Lin, 2019).

Despite growing interest, academic research into OEI is currently in its infant stage, and the concept itself is not yet clearly defined (González-Moreno et al., 2019). Apart from an empirical examination of the benefits and determinants of OEI adoption and implementation, this line of research requires a more comprehensive theoretical analysis of its bases and a better systematization of the knowledge so far developed.

As far as we are aware, there only exist one bibliometric and four literature reviews focused on OEI and collaboration during eco-innovation R&D. They include a systematic literature reviews of the sustainable open innovation concept by Perl-Vorbach et al. (2014) and Rauter et al. (2017), a systematic literature review of collaboration in green product innovation by Melander (2017), a systematic literature review of interorganizational cooperation in eco-innovation (Pereira et al., 2020) and a bibliometric study focused on the use of OI and collaboration in sustainable eco-innovation by Fernandez (2019). To further the understanding of OEI and identify the main topics and thematic gaps in research, we also perform a comprehensive bibliometric

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study.

Compared to previous work, this study significantly expands the observation period, contributes additional historical context to research into OEI, and adds the most recent theoretical advances to the analysis. It also includes a much greater variety of EI and OI synonyms to the search string, giving a more complete overview of the research so far undertaken. We believe that this is the first bibliometric study to use data simultaneously from both the WoS and Scopus databases, providing a more accurate and representative overview of research into OEI.

Our research makes a twofold contribution. Firstly, we present the most complete assessment so far of academic contributions to OEI research. It demonstrates the growing interest in the topic, the relationships between the various disciplines constituting this research, and the currently fragmented and isolated patterns of OEI analysis. Secondly, we use a quantitative approach to identify the main clusters, themes, and topics of conversation in OEI research, analyze them through the prism of three levels of analysis (micro, meso, and macro), and identify the main thematic gaps to be resolved in future studies.

The theoretical contribution of this paper lies in its intention to unite the various manifestations of OEI under one umbrella term. This will allow researchers to find common ground and a more complete perspective for their otherwise isolated research endeavors. As a result, collaborative dynamics and methods, the choice of partners, the search for external knowledge, patenting activities, and internal resources and capabilities become part of a more comprehensive OEI company strategy and are analyzed as such.

The article is structured in 6 sections. Section 2 provides a brief analysis of the eco-innovation and open innovation concepts, explores the various definitions of OEI and summarizes previous bibliometric and literature reviews of OEI. Section 3 is dedicated to the methodology chosen and offers information about the benefits of bibliometric analysis. Section 4 presents the bibliometric results, listing the dynamics of current research into OEI, including the number of publications on the topic, its prominent authors, their studies and their geographical distribution, the leading academic journals in the area, and cluster analysis of critical papers, based on co-authorship and co-occurrences of keywords. Section 5 provides an in-depth content analysis of each of the clusters and their position in research, according to the multilevel approach to analysis. Finally, Section 6 concludes the article, with a summary of the main findings of the paper, an outline of its limitations and avenues for future research into OEI.

## 2. Theoretical background

### 2.1. What is open eco-innovation?

The concept of OEI represents the idea of using open innovation (OI) strategies to develop eco-innovations (EI).

#### 2.1.1. What is eco-innovation?

Eco-innovation is intended to improve the environmental performance of organizations (Carrillo-Hermosilla et al., 2010). Both academics and practitioners view it as a critical element in the transition to a more sustainable future (Del Río et al., 2015). Although promising, its adoption by companies is still slow and challenging at many levels.

Sustainable innovations and eco-innovations are considered to be more complex than other types of innovations (Perl-Vorbach et al., 2014). They are driven by different motivations and face the problem of double externality when involuntary knowledge spillovers reduce the incentives of firms to invest in EI (Renning, 2000), or even a triple externality problem when other organizations do not take advantage of these spillovers (adoption externalities) (Dybvig and Spatt, 1983). Del Río et al. (2010) identify three significant barriers to EI: the external environment (lack of pressure from stakeholders to eco-innovate), internal company conditions (lack of financial resources, low technological competency), and the techno-economic characteristics of EI (high

cost and incompatibility with the existing production process). As a result, despite the growing evidence that EI in companies is positively associated with economic and environmental performance, competitive advantage (Chen et al., 2006), and a green image (Zhang et al., 2018), companies are still struggling to grasp the benefits of EI implementation.

One way for firms to cope with EI barriers and challenges is to collaborate with external institutions, organizations and individuals (del Río González, 2009). Logically, inter-organizational collaboration helps to cope with the EI barriers mentioned above. Firstly, it helps overcome internal organizational constraints through access to external financial resources, technologies and knowledge. Secondly, the risk associated with the high cost of EI development may be shared among several partners. Thirdly, through a closer connection with stakeholders, organizations may increase compliance with laws and regulations (Bengtsson, 2020), improve process efficiencies (Fabrizi et al., 2018), and be more aware of any disruptive changes and opportunities evolving in the industry (Ben Amara and Chen, 2020).

In the preceding decade, several empirical studies have confirmed the importance of collaboration for EI (De Marchi, 2012b; Mazzanti and Zoboli, 2009; Rennings and Rammer, 2011; Wagner, 2009). They showed that eco-innovation requires more cooperation than other innovations, given their systemic and complex character, and that eco-innovators must leverage the competencies of external partners to a greater extent than other innovators (De Marchi, 2012a). It was also argued that “successful eco-innovations are highly dependent on the participation of various stakeholders in their development/uptake, i.e., they are “likely to result from cooperation among different units and the formation of partnerships between the public sector, academia and business.” (Carrillo-Hermosilla et al., 2010, p.1082). Finally, collaboration is considered to be one of the most critical competencies for the design process in the circular economy (Sumter et al., 2020), where different types of cooperation may affect the radical nature of circular innovations (Brown et al., 2020).

The most recent research considers inter-organizational collaboration during EI to be a part of an open innovation strategy, namely a more comprehensive approach of organizations to use external resources (tangible and intangible) to develop EI, as well as to commercialize internally created EI technologies (González-Moreno et al., 2019; Triguero et al., 2018).

#### 2.1.2. What is open innovation?

The term “open innovation” was coined by Henry Chesbrough in 2003 and has experienced rapid growth. He defines OI as “a distributed innovation process based on purposively managed knowledge flows across organizational boundaries, using pecuniary and non-pecuniary mechanisms in line with the organization’s business model” (Chesbrough and Bogers, 2014, p. 18), and as “an innovation model that emphasizes purposive inflows and outflows of knowledge across the boundary of a firm to leverage external sources of knowledge and commercialization paths, respectively” (Chesbrough and Bogers, 2014, p. 16).

The guiding principles of OI suggest that significant value is created both inside and outside the firm and that it may be captured through an appropriate business model to make optimum use of internal and external talents and ideas (Chesbrough, 2003). In practice, the process of OI may take various forms, depending on the objectives of the organization. Chesbrough and Bogers (2014) distinguish between outside-in (inbound) OI, inside-out (outbound) OI, and coupled OI. Inbound OI brings technologies, knowledge and ideas from outside the firm to complement internal R&D activities, and may take the form of in-licensing intellectual property, technology scouting, crowdsourcing, the use of intermediaries, the organization of competitions and challenges and community building. Outbound OI focuses on commercializing under-utilized assets and internally developed technologies through the out-licensing of intellectual property and technologies, spin-offs, corporate venture capital and corporate incubators. Coupled

OI uses the purposive inflows and outflows of knowledge across company boundaries to develop and/or commercialize new technologies collaboratively; this occurs through strategic alliances, joint ventures, consortia, networks, ecosystems and innovation platforms.

### 2.1.3. What is open eco-innovation?

In recent years, OI researchers have begun to explore this concept in the context of sustainability and its potential to resolve the major challenges we face as a society (Bogers et al., 2020). We have identified several attempts to define Open Eco-innovation (OEI) more formally during our research. One of the first approximations was made by Winston (2010). The author uses the term “open (green) innovation” and defines it as a way of sharing ideas and patents among several companies to jointly reduce their environmental impact. He also suggests that this concept is a combination of open innovation and sustainability research areas. One of the most widely accepted definitions of OEI was proposed by Ghisetti et al. (2015, p. 1081) who named the concept “open eco-innovation mode” and defined it as “environmentally friendly modes of knowledge sourcing and absorption, along with connectedness with environmentally responsible partners and embeddedness in the green-oriented innovation system.” They believed that such openness to external knowledge sources is beneficial in the discovery of solutions to the internal constraints of firms in the development of EI. This version of the definition was later adopted by Fabrizi et al. (2018) and Kobarg et al. (2020).

Another significant stream of literature and definitions focuses on the use of open innovation strategies to develop sustainable innovations, a broader concept that includes the development of both eco-innovations and social innovations (Perl-Vorbach et al., 2014). Arcese et al. (2015, p. 8080) use the term “open sustainability innovation” and define it as “an approach by which open innovation practices merge with the sustainability concept.” Perl-Vorbach et al. (2015, p.6) use the term “sustainable open innovation” or “open innovation for sustainable innovation?” and define it as “an outside-in process, whereby external knowledge is gathered to support the internal development of sustainable innovation.”

More recent studies approach OEI as “openness in environmental innovation”, defined as a search for external knowledge through information sourcing, R&D acquisition, and sharing strategies (Mothe and Nguyen-Thi, 2017, p.2); or “open environmental innovation,” defined as “the possibility to complement the internal investment in green-specific resources with knowledge and competences coming from network partners” in order to introduce eco-innovation (de Marchi and Grandinetti, 2013, p. 571; Russo Spena and Di Paola, 2020, p. 3). Garcia et al. (2019, p.5) define OEI as “the development of innovations utilizing inflows and outflows of knowledge to accelerate internal innovation and expand the market for innovations created with partners outside the firm, with one of the goals of achieving a positive impact on society, the environment, or both.” Finally, the latest studies of the Circular Economy also emphasize that the concept is systemic and inherently collaborative. Brown et al. (2019, p.3) introduce the term “collaborative circular oriented innovation” and define it as “coordinated (collaborative) activities that integrate Circular Economy goals, principles, and recovery strategies into technical and market-based innovations.”

Our research takes OEI to be the purposive use of open innovation strategies in the process of eco-innovation R&D and defines it with the combination of the open innovation definition of Chesbrough and Bogers (2014) and the definition of eco-innovation by Carrillo-Hermosilla et al. (2009). As a result, Open Eco-innovation is the use of purposive inflows and outflows of knowledge, resources and commercialization paths to develop and/or adopt innovations improving the environmental performance of firms. The variety of terms and definitions related to OEI is summarized in Table 1.

In summary, all the proposed definitions underline several essential features of OEI. Firstly, the main goal of OEI is to reduce the environmental impact of organizations. Secondly, OEI is focused principally on

**Table 1**  
**Definitions of Open Eco-innovation.**

Term	Definition	References
Open (green) innovation	a combination of OI and sustainability. A way to share ideas and patents among several companies in order to reduce their cumulative environmental impact	Winston (2010)
Open environmental innovation	“the possibility to complement the internal investment in green-specific resources with knowledge and competencies coming from network partners as a major driver for the introduction of eco-innovations.”	de Marchi and Grandinetti (2013, p. 571); Russo Spena and Di Paola (2020, p.3)
Open eco-innovation mode	“environmentally friendly modes of knowledge sourcing and absorption, along with connectedness with environmentally responsible partners and embeddedness in the green-oriented innovation system.”	Ghisetti et al. (2015)
Open eco-innovation mode (OEIM)	openness to external knowledge sources which may help firms attenuate internal constraints and gain sustainability	Ghisetti et al. (2015); Kobarg et al. (2020); Fabrizi et al. (2018)
Sustainable Open Innovation/Open innovation for sustainable innovation	“an outside-in process, whereby external knowledge is gathered to support the internal development of sustainable innovation.”	Rauter et al. (2015, p.6)
Sustainable open innovation	“a distributed innovation process which is based on purposively managed knowledge flows across organizational boundaries, using pecuniary and non-pecuniary mechanisms in line with the organization’s business model, thereby contributing to development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”	Bogers et al. (2020, p. 1507)
Open sustainability innovation	“an approach by which open innovation practices merge with the sustainability concept.”	Arcese et al. (2015, p. 8080)
Openness in environmental innovation	“holistic approach to external knowledge search through information sourcing, R&D acquisition, and sharing strategies.”	Mothe and Nguyen-Thi (2017, p.2)
Open eco-innovation	“development of innovations utilizing inflows and outflows of knowledge to accelerate internal innovation and expand the market for innovations created with partners outside the firm, with one of the goals of achieving a positive impact on the society, the environment, or both”	Garcia et al. (2019, p. 5)
Open eco-innovation	“The use of purposive inflows and outflows of knowledge, resources, and commercialization paths to develop and/or adopt innovations that improve the environmental performance of the firm.”	Chistov et al. (2021)

(continued on next page)

**Table 1** (continued)

Term	Definition	References
Collaborative Circular Oriented Innovation	"coordinated (collaborative) activities that integrate Circular Economy goals, principles, and recovery strategies into technical and market-based innovations."	Brown et al. (2019, p.3)

Source: Own elaboration

information and knowledge flows (outside-in and inside-out), although it may also include access to external physical and financial resources. Thirdly, OEI helps to overcome the internal constraints of organizations and accelerates internal innovation. Fourthly, knowledge and information are sourced through cooperation with external partners, acquisition of R&D and embeddedness in the green-oriented innovation ecosystem. Finally, intellectual capital generated in the process of OEI can be patented, registered, and shared (licensed) outside the organization, thereby creating new sources of revenue and scaling the overall benefits of the firm's eco-innovations for the general good of society and the environment.

## 2.2. Bibliometric and literature review studies of open eco-innovation

Several recent studies have been aimed at providing insights into the topic of OEI through structured literature and bibliometric reviews. For instance, [Perl-Vorbach et al. \(2014\)](#) performed a literature review of 12 papers encountered in the major citation databases (including the Thomson Reuters Web of Science (WoS) and Scopus) between 2003 and 2013, to evaluate the possible benefits and barriers of using open innovation for sustainable innovation. [Rauter et al. \(2017\)](#) analyzed 19 publications from 2003 to 2015 through systematic explorative analysis and proposed a framework encompassing the internal and external innovation systems of organizations, possible partners (stakeholders), aspects of cooperation and cooperation methods for sustainable open innovation. [Melander \(2017\)](#) conducted a systematic literature review of publications from the WoS database in the 1990 to 2015 timeframe, to identify and categorize the drivers of collaborative green product innovation. [Fernández \(2019\)](#) performed a bibliometric analysis of 57 publications from the Scopus database (available till March 2018) and presented data on the geographic distribution of the publications, prominent authors and journals focusing on the topic. Finally, [Pereira et al. \(2020\)](#) reviewed 35 publications in the WoS database published in 2011–2019 and proposed a framework for research into inter-organizational cooperation based on the 5W2H quality management tool, which structures analysis based on the questions: why, what, how, how much, where, when, and so what.

These contributions have taken an essential step to the understanding and mapping of the OEI field. Nevertheless, while all of them explore the purposive use of collaboration and external resources to develop EI, due to the choice of the keywords, they examine the separate manifestations of OEI rather than analyze the concept as a whole. For instance, [Perl-Vorbach et al. \(2014\)](#) and [Rauter et al. \(2017\)](#) focused explicitly on OI in the sustainability context. They used the keyword "open innovation" combined with "sustainability" and the possible variations such as sustainable/eco/green/environmental OI. [Melander \(2017\)](#) centered her research around keywords related to collaboration in EI, for example, customer collaboration or collaborative R&D. The bibliometric analysis by [Fernández \(2019\)](#) includes both "open innovation" and "collaboration" keywords together with EI and "environmental innovation," although only at the firm level. [Pereira et al. \(2020\)](#) use the keywords of network, cooperation, partner, and alliance, but do not consider anything related to OI and collaboration. None of these studies included publications associated with the use of external knowledge to develop EI, and neither did they comprise activities to

pursue outbound OEI and commercialize internally developed EI.

The coverage of the entire spectrum of OEI studies may also be affected because all of the previous bibliometric and literature reviews employ different timeframes to collect articles and base their research on only one citation database, WoS or Scopus (except for the literature review by [Perl-Vorbach et al. \(2014\)](#)). While it is true that the term OI was only coined in 2003, organizations used collaborative activities and searched for external resources to develop eco-innovations long before. The two major citation indexes overlapped to a maximum of 50% ([Tabacaru, 2019](#)). These discrepancies may be the result of the lack of a clear definition of OEI and an imprecise delineation of the research boundaries of the topic. Finally, although authors were able to identify certain critical issues of discussion in the OEI research through literature review, there are no current studies using more quantitative bibliometric and science mapping tools to identify the main clusters, themes and topics in research into the OEI concept.

We aim to contribute to a better understanding of OEI through a review of the main topics in the related literature and a discussion of the research gaps to be addressed. We are interested in the following research questions.

1. What are the main clusters of discussion topics in OEI research?
2. What are the main thematic gaps in OEI research?

In order to answer these questions and cover the research gaps, we perform a new bibliometric and content analysis that includes a more complete spectrum of keywords related to OEI and a lengthier timeframe for the study; we also use the two citation indexes, WOS and Scopus, simultaneously for the bibliometric and cluster analysis. Additionally, we explore the existing definitions of OEI and propose a new one; we use quantitative bibliometric methods to present OEI research in a more organized and quantifiable manner and identify its main topic clusters, using a multilevel approach to summarize them through a simplified conceptual model which will help to visualize the current dynamics in this research area. Finally, we identify the gaps in OEI research and propose new avenues for future studies.

## 3. Methodology

To answer our research questions and provide an accurate representation of the current state of the literature on OEI and collaborative activities in the process of eco-innovation, we employ a two-tier analysis comprising the systematic approach to the literature review and further bibliometric analysis of articles collected from the Web of Science and Scopus databases, as well as further content analysis.

A systematic and organized approach to the literature review is a way of reading, categorizing and analyzing academic papers ([Dahlander and Gann, 2010](#)). This helps to narrow the search for academic knowledge on the topic to its essential contributions and allows transparency and replicability of the methodological process ([Todeschini et al., 2020](#)). While there exist various approaches to the number and order of the key steps in a systematic literature review, the current paper follows the methodological approach of [Usman et al. \(2018a,b\)](#), previously used in research into open innovation. It includes a selection of databases (stage 1), a selection of keywords for the search string (stage 2), a selection of relevant papers (stage 3), and an application of inclusion and exclusion criteria (stage 4).

After the systematic literature review, the relevant publications were assessed using specialized bibliometric and science mapping software (stage 5). Bibliometrics uses mathematical methods and statistics to analyze and measure the meta-data of publications (articles, books and book chapters, among others) to organize and analyze information and examine bibliographical material. In the preceding decade, bibliometric methods have been successfully used in the literature on eco-innovation and open innovation to measure quantitative and qualitative research, uncover emerging themes and trends in the field, detect and map

research clusters and identify the impact of individual authors or research groups (Taddeo et al., 2019).

Fig. 1 illustrates the research protocol followed to conduct our study, and the accompanying text discusses each stage of the process.

### 3.1. Stage 1. Selection of citation indexes

We based our bibliometric and systematic literature review on publications included in the Web of Science (WoS) and Scopus databases. They are the most widely consulted citation indexes worldwide, and consequently, most bibliometric and scientometric tools are built upon them (De Groot and Raszewski, 2012). Authors tend to use only one of the databases, in particular during the bibliometric reviews, due to the technical complexity of combining the data. The validity of such analysis is sometimes questioned, as the coverage of each index is limited and may not represent the full scope of scientific activity in a particular field (Monge and Paul-Hus, 2016). Studies show that these two databases tend to overlap only by 49–50% (Tabacaru, 2019). Consequently, we perform our analysis based on both WoS and Scopus databases.

### 3.2. Stage 2. Selection of keywords for the search string

The identification of keywords related to OEI is a challenging process, as both facets of the concept (eco-innovation and open innovation) are defined by various interchangeable terms and overlapping concepts, making research slower and less consistent. We based keyword selection on the previous bibliometric articles.

Randhawa et al. (2016) stated that besides “open innovation,” the concept of OEI can also be related to such terms as “collaborative innovation,” “openness,” “crowdsourcing,” and “co-creation.” Usman et al. (2018a,b) introduce additional terms, including: “inbound innovation,” “outbound innovation,” and “coupled innovation.” In the bibliometric analysis of open innovation strategies in solar energy technologies, de Paulo and Porto (2017) add the terms “collaboration,” “cooperation,” “external technologies,” and “flows of knowledge.” These keywords were also used in the work of Melander and Pazirandeh (2019). Based on the initial assessment of the literature, we also included such terms as partnership (Kennedy et al., 2017), co-design (Mogensen et al., 2012), alliance (Pereira et al., 2020), “external resources,” and “external knowledge” (Mothe et al., 2018).

According to Franceschini et al. (2016), research into EI can be identified with such terms as: “eco-innovation,” “green innovation,” “environmental innovation,” and “sustainable innovation.” These keywords are also used in earlier bibliometric articles by Albort-Morant et al. (2017), Fernandez (2019) and Melander (2017).

The final search string for our bibliometric analysis is comprised of the following keywords, included in titles, keywords, and abstracts:

((“open eco-innovation”) OR ((“eco-innovation” OR “green innovation”) OR “environmental innovation” OR “sustainable innovation”) AND (“open innovation” OR “collaborative innovation” OR “inbound innovation” OR “outbound innovation” OR “coupled innovation” OR “collaboration” OR “cooperation” OR “partnership” OR “co-design” OR “co-creation” OR “external resources” OR “external knowledge”)))

### 3.3. Stage 3. Data collection and processing

Using the search string, we ran the search in both databases in February 2021. We received 472 articles from WoS and 535 articles from Scopus. Additional articles related to OEI research were found in reference lists during the exploration of the academic literature for sections 1 and 2. When relevant, they were discussed in the text, and 17 of them were included in the combined database, which was later used in the bibliometric analysis.

### 3.4. Stage 4. Inclusion criteria

The review of identified citations was performed in three steps: elimination of duplicates, analysis of articles according to inclusion and exclusion criteria, and a content reading and check based on titles, abstracts, and keywords. For a better understanding of the concept of OEI, we intentionally adopted very broad inclusion and exclusion criteria for collaborative activities in eco-innovation, summarized in Table 2.

After the first step (elimination of duplicates), we identified a population of 735 articles. After the second and the third step, only 521 publications were considered relevant for further analysis. From among them, 17 additional articles were not matched with a particular database, 252 citations (50%) overlapped between the two databases, 106 citations (21%) proceeded only from WoS, and 146 (29%) proceeded only from Scopus. Exclusive use of WoS captures only 71% of the current literature on OEI, and exclusive use of Scopus captures only 79%, leaving a significant portion of the literature uncovered. To conclude, the simultaneous analysis of both databases is essential and should be encouraged in further research into OEI.

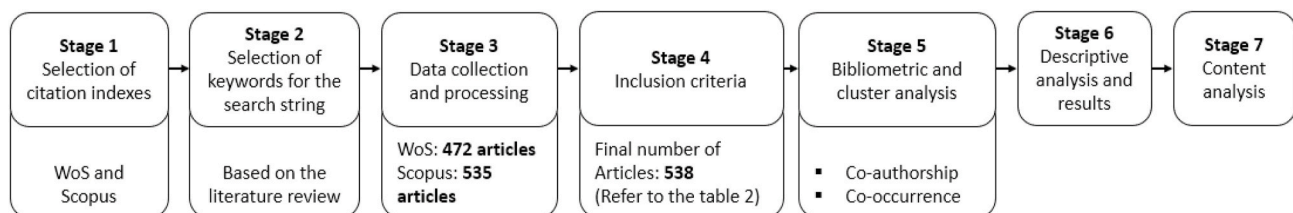
### 3.5. Stage 5. Bibliometric analysis

We used VOSviewer to create, visualize, and explore bibliographic data for OEI research. This bibliometric software has been successfully applied for over a decade (van Eck and Waltman, 2010). It is used to construct networks of items: researchers, scientific journals, countries, keywords and publications connected through links based on co-authorship, co-occurrence, citation, bibliographic coupling, or co-citations. VOSviewer items are grouped, based on their weight, (total number of links and total link strength) into non-overlapping clusters (van Eck and Waltman, 2010). Further cluster analysis allows the

**Table 2**  
Inclusion criteria for materials on Open Eco-innovation.

No.	Criteria	Description
1	Period	1990 to 2020
2	Document type	Articles
3	Language	English
4	Research type	Theoretical, conceptual, empirical, qualitative, quantitative, methodological, literature reviews
5	Collaboration type	Any collaboration leading to the R&D of eco-innovations and consequently affecting the environmental performance of firms

Source: Own elaboration



**Fig. 1. Research design.**  
Source: Authors' elaboration.

separation of the sample into smaller, homogeneous groups that can be clearly differentiated and explored (García-Granero et al., 2020).

Citation and co-citation analysis, bibliographic coupling, co-authorship analysis, and analysis of co-occurrence of the keywords are differing but interchangeable approaches to cluster research into a particular topic. Recent high-quality papers tend to use co-citation and bibliometric coupling approaches. The literature shows that clustering based on direct citations is the least accurate approach and that bibliometric coupling outperforms co-citation analysis (Boyack, 2010). We built the cluster models based on these approaches, but the final results did not truly represent research into OEI, and nor did they contribute to our research goal of identifying the main topics of OEI research. For instance, the bibliographic coupling analysis groups authors based on the number of shared references, but since the topic of OEI is new, most of these are general articles related to eco-innovation or open innovation and do not represent OEI research in any way. The same is true for co-citation analysis, as it groups authors based on mutual citation. Due to the novelty of the topic, authors cite the general contributions of peers to eco-innovation and open innovation, and not necessarily the papers on OEI. As a result, we based our cluster analysis on keyword co-occurrence; this groups research based on keywords tending to appear together in titles and abstracts of articles, giving a more objective perspective to OEI research and providing useful information about the topics of conversation in this field.

#### 4. Descriptive analysis and results

Fig. 2 illustrates the number of relevant publications extracted from WoS and Scopus. The first publication in our selection of articles is dated from 1992 and discusses the Danish Clean Technology Program, which aimed to bring together polluters, suppliers and consultants to develop environmental innovations (Georg et al., 1992).

While we were able to identify related publications from as early as 1992, the real interest in the topic of collaboration in EI started in 2010, and the number of articles grows every year, in some cases exponentially. More than 50% of the articles were produced from 2017 to 2020. The actual use of the term Open Eco-innovation is still limited to only a few publications (Fabrizi et al., 2018; Garcia et al., 2019; Ghisetti et al., 2015; González-Moreno et al., 2019; Laperche and Picard, 2013). Nevertheless, it is growing rapidly, and more and more authors are currently employing the term OEI.

Research is mostly performed in Europe (Fig. 3), with a notable

number of publications coming from Spain (62), Italy (53), Netherlands (46), UK (36), Germany (35), Sweden (27), France (21) and Denmark (21). This may be attributed to stricter environmental regulation and control in developed countries. Research is also undertaken in the USA (30) and Brazil (27) and Asian authors are as well joining the conversation, China being the prominent leader (52). Fig. 3 shows the timeline when authors from various countries joined the academic conversation on collaboration for eco-innovation and OEI. The largest producers of such research came to prominence before 2013, but today research is contributed by authors from a much wider variety of countries.

Although OEI research is distributed among more than 50 journals, three of them account for the majority of published articles (Fig. 4): Journal of Cleaner Production (70 articles), Sustainability (54), and Business Strategy and the Environment (28). The top three journals are in Q1, Q2 rank quartile, with impact factors of 6.395 (Journal of Cleaner Production, 2018), 6.381 (Business Strategy and the Environment, 2018), and 2.592 (Sustainability, 2018). The attention paid by highly indexed journals to this topic is further confirmation of its importance and value.

The next part of the descriptive analysis is dedicated to researchers engaged in collaborative activities in eco-innovation. We chose bibliometric cluster analysis based on co-authorship, with authors as the study unit, and used the full counting method (Fig. 5).

The number of documents per author were selected as visualization weights. Fig. 5 shows that there currently exist three major research groups into OEI. They are associated with the University of Castilla - La Mancha (Spain), the University of Padua (Italy), and the Spanish National Research Council (CSIC). However, most research is performed by small research teams or individuals working in isolation, without intensive interaction and unbound by any academic association.

To identify the significant topics of research into OEI we performed a cluster analysis based on the number of co-occurrences of the keywords in the articles, also using VOSviewer. The initial sample of 2325 was reduced to keywords with at least nine occurrences, resulting in 69 keywords which met the threshold. The final results revealed four distinct clusters in OEI research, with a total number of 1155 links (Fig. 6).

More detailed information on keyword clusters and their respective weights (number of occurrences and total link strength) is presented in Fig. 7.

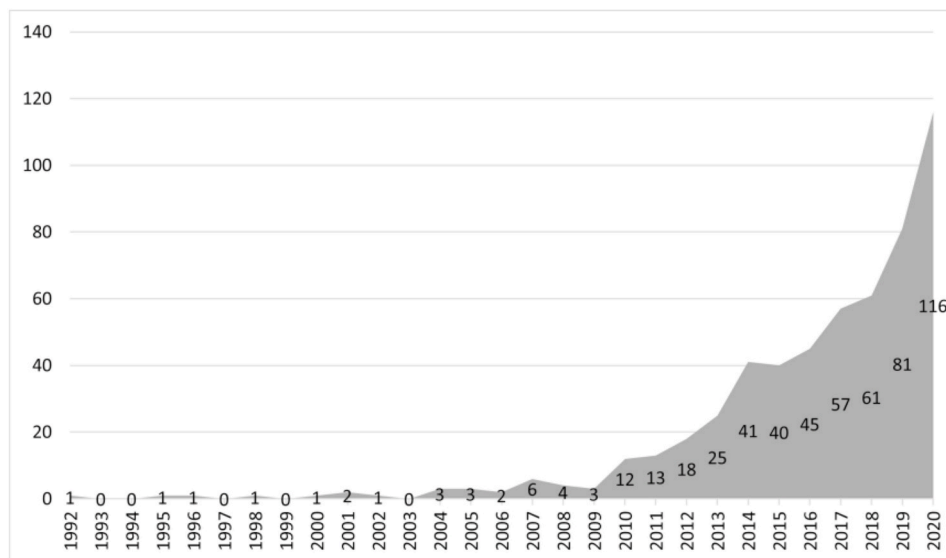


Fig. 2. The number of publications related to Open Eco-innovation per year. Source: Authors' elaboration

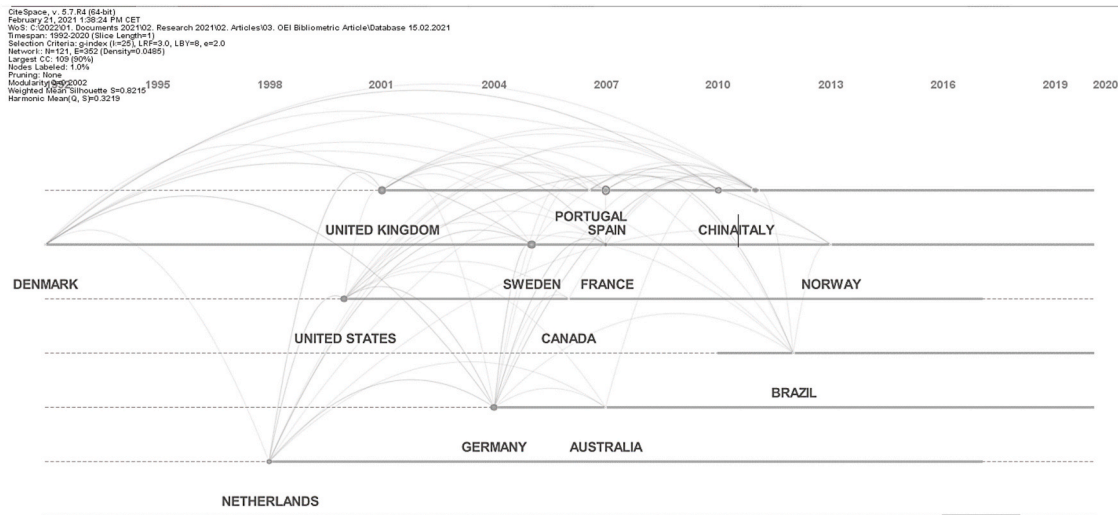


Fig. 3. The timeline of when authors from various countries joined the OEI conversation.  
 Source: Authors' elaboration with CiteSpace 5.6

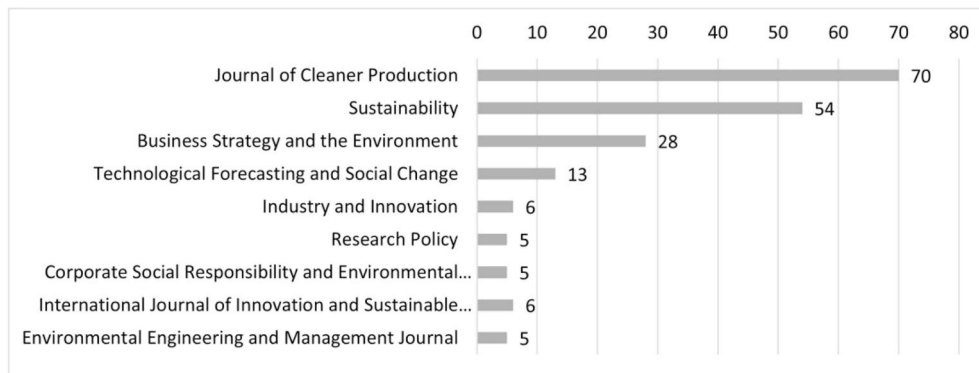


Fig. 4. Open Eco-innovation research in academic journals.  
 Source: Authors' elaboration

5. Discussion

The results of this bibliometric study identified several important patterns in OEI research; these are analyzed and discussed in the following section.

Firstly, OEI is an emerging topic of conversations in the literature on both EI and OI, and the number of their publications is growing rapidly, although the variety of synonyms and perspectives on the subject and its lack of clear nomenclature make it difficult to unify various definitions of OEI under one umbrella term. As a result, research into OEI is fragmented, with authors tending to explore its isolated characteristics rather than considering them as parts of a more comprehensive strategy. We believe that using the universal term “open eco-innovation” may unite researchers working on this topic but currently separated by differences in terminology.

Secondly, the examination of keyword co-occurrence revealed four significant clusters in OEI research, each cluster defined by a set of topics (keywords) tending to appear together. As a conceptual framework for the analysis of these clusters, we decided to utilize the multilevel perspective, commonly used in research into sustainable transition. Using this perspective, authors distinguish between micro-, meso- and macro levels of processes and levels of analyses (Smith et al., 2010), although there exist variations in the understanding of what constitutes each of these levels (del Río et al., 2017). A more common approach relates each level of analysis to the levels of innovation systems. For

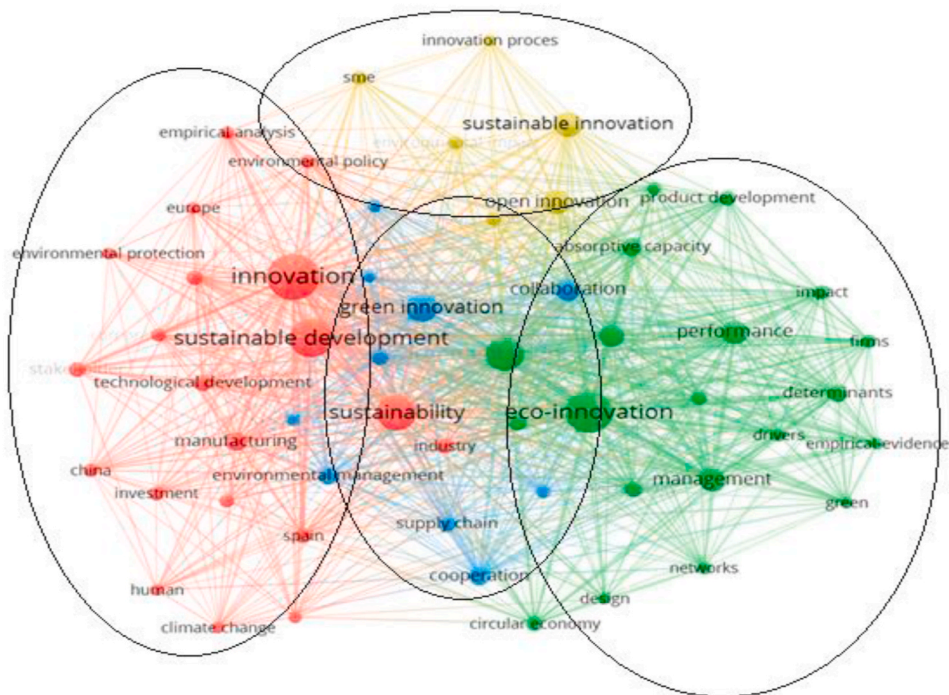
instance, Ghazinoory et al. (2020) distinguish between macrolevel (global innovation systems, national innovation systems and national open innovation systems), mesolevel (regional innovation systems, sectoral innovation systems, technological innovation systems, and social innovation systems), and microlevel (organizational innovation systems). The literature on Circular Economy understands the micro-level as the level of products, companies, and consumers, the mesolevel to be the level of interfirm networks, the green supply chain, symbiosis associations, and the macrolevel as the level of cities, regions, and nations (Kiefer et al., 2021). In the context of OEI, authors use the same terms to distinguish between value creation and capture at the organizational level (microlevel), the level of co-creation and collaboration among stakeholders (mesolevel), and the level of society and the natural environment (macrolevel) (Garcia et al., 2019). Fig. 7 illustrates the relationship between levels of analysis, clusters, and topics.

5.1. Macro-level of open eco-innovation

The macro-level of analysis in OEI research is represented by cluster 1. It is comprised of terms innovation and sustainable development, as well as sustainability, manufacturing, technological development, environmental economics, stakeholder, industry, environmental policy and regulation, climate change and environmental protection. This level is dominated by topics of political economy and the role of governments in the sustainable development of nations. It also represents the



**Fig. 5. Analysis of co-authorship in Open Eco-innovation research.**  
Source: Authors' elaboration with VOSviewer.



**Fig. 6. Cluster analysis of Open Eco-innovation research based on co-occurrences of the keywords.**  
Source: Authors' elaboration with VOSviewer

<b>Macro-level</b>	<b>Cluster 1</b> Innovation (141/479) Sustainable development (99/330) Sustainability (83/299) Manufacturing (25/88) Technological development (18/78) Environmental economics (16/86) Stakeholder (16/53)	
<b>Meso-level</b>	<b>Cluster 2</b> Green innovation (52/174) Collaboration (32/122) Cooperation (25/104) Environmental management (22/97) Supply chain management (19/86) Supply chain (17/57) Environmental performance (12/63) Case study (11/46) Environmental sustainability (11/49) Green supply chain (11/44)	<b>Cluster 3</b> Sustainable innovation (42/106) Open innovation (40/107) Knowledge management (13/59) SME's (13/42) Environmental impact (12/43) Innovation process (10/29)
<b>Micro-level</b>	<b>Cluster 4</b> Eco-innovation (116/390) Environmental innovation (77/310) Performance (38/178) Management (37/184) Research and development (33/162) Absorptive capacity (22/88) Determinants (20/120) Knowledge (20/100)	

Fig. 7. Representation of OEI research based on levels of analysis, clusters, and topics (with respective weights: number of occurrences and total link strength).

Source: Authors' elaboration.

environment and determinants of OEI that are external to the firm. At the macro-level, the essential idea of collaboration with partners during the eco-innovation process dates back to the development of major environmental movements and intergovernmental environmental resolutions of the twentieth century, when regional, continental, and planetary collaborations were seen as a way of preserving the habitability of the planet (Udall, 1971).

Throughout the 80s and 90s, many advances in eco-innovations (clean technologies) were performed through collaborative research activities between companies and research centers and subsidized by national governments. Examples of such initiatives are the West Germany Ministry of Research and Technology (BMFT) Program, in force from 1973 to 1986, (Bongaerts and Heinrichs, 1987) or the Danish Clean Technology Program (Georg et al., 1992). These provoked further academic discussion on the importance of stakeholder engagement for organizations and its embeddedness in green-oriented innovation systems for sustainable and technological development. Our analysis shows that academic research into OEI is commonly performed in the context of stakeholder theory; it recognizes that external stakeholders have the power to facilitate green product innovation and contribute to corporate environmental performance (Lee and Kim, 2011).

Another important group of articles in this cluster explores the importance of combining stakeholders into networks of sustainable industrial knowledge and the positive effects of industrial symbiosis. According to Mirata and Emtairah (2005), Industrial Symbiosis (IS) programs aim to use the spatial proximity of industrial activities to respond to environmental concerns and catalyze inter-organizational collaboration among local economic actors to harvest the potential for environmental improvement present at the inter-organizational interface. Authors emphasize the crucial role of inter-organizational and inter-sectoral collaboration during eco-innovation R&D and discuss the importance of a coordinating intermediary to facilitate information flows, ensure the commitment of involved parties and enable

communication among them. The benefits of such collaboration include economic cost savings, learning in various forms and further promptness in continuing company eco-innovation activities.

## 5.2. Meso-level of open eco-innovation

The meso-level of OEI research includes clusters 2 and 3. This level of analysis focuses on the dynamics of collaboration among partners in the knowledge network.

Cluster 2 includes such topics as green innovation, collaboration, cooperation, environmental management, and a well-defined section on green supply chain management. This is a more applied type of research, where authors focus on real-life examples of collaboration along the value chain and manufacturing processes to create green innovations and increase company environmental performance. So far, research in this cluster has focused on empirically proving the positive effects of collaboration in EI (Adomako, 2020; Meirun et al., 2020), the choice of partners (Aboelmaged, 2018), and the depth and breadth of collaboration (Garcés-Ayerbe et al., 2019).

Collaboration has long been seen to be one of the crucial drivers of eco-innovation, and many important empirical investigations have been able to demonstrate this (Mazzanti and Zoboli, 2009; Wagner, 2009). Some authors argue that collaboration and OEI strategies are even more important for EI than for common innovation (da Silva Rabêlo and de Azevedo Melo, 2019; De Marchi, 2012a), and that they are indispensable in circular-oriented innovations based on the collaborative approach and close cooperation with partners along the value chain (Massaro et al., 2020). However, recent findings also show that an overwhelming majority of firms engaged in eco-innovation (EI) did not cooperate and share resources and infrastructure with other firms (Liu and Bai, 2014; Ormazabal et al., 2018).

The second main topic in cluster 2 is related to the choice of partners in OEI. Current research explores examples of collaboration with

universities, government agencies, research centers (Bartlett and Trifilova, 2010; Georg et al., 1992; Scarpellini et al., 2012), suppliers (Aboelmaged and Hashem, 2019; Geffen and Rothenberg, 2000), customers, users and investors (Aka, 2019). Several authors have shown that different types of eco-innovations benefit differently from collaboration with particular kinds of stakeholders (Melander, 2018).

A distinct stream of literature in this cluster focuses on collaboration with suppliers. Geffen and Rothenberg (2000) see such close cooperation as a mutually beneficial process to develop eco-innovations. Some researchers note that the ability to draw on supplier expertise and relationships enhances the capacity of firms to support more radical eco-innovations while maintaining production quality and cost goals. From a supplier's perspective, close cooperation with its customers also increases the innovation level of the firm and helps to better satisfy its needs. Gold et al. (2010) consider building and maintaining effective cooperation with suppliers is part of company competence and capability, creating an environmental and social added value to secure its competitive advantage.

The third important topic that currently dominates cluster 2 is the depth and breadth of collaboration; different types of eco-innovations require different degrees of cooperation. For instance, compared to incremental innovations, systematic and radical types of eco-innovation require greater financial resources, more internal innovation capabilities and a higher degree of collaboration with external partners (Kiefer et al., 2019). The level of cooperation in OEI is currently measured by two main parameters. Firstly, the breadth of knowledge sourcing (collaboration breadth), that is to say the number of external information sources the firm relies upon (Fabrizi et al., 2018; Ghisetti et al., 2015; Mothe et al., 2018), and secondly the depth of knowledge sourcing (collaboration depth) or the number of external information sources to which firms attribute great importance (Fu and Fu, 2020; González-Moreno et al., 2019; Hou et al., 2017; Mothe et al., 2018).

Another important group of topics at the meso-level is cluster 3. It includes such keywords as sustainable innovation, open innovation, knowledge management, SMEs, environmental impact and the innovation process. This cluster focuses on the ability of open innovation strategies to foment the development of sustainable innovations, including eco-innovations, while decreasing the firm's environmental impact. It explores the innovation process of organizations when they exchange and manage knowledge to create shared value. The low total number of links and occurrences of the terms in this cluster indicates the lack of research on the matter and its weak connection to other OEI research topics. Research in this cluster comes mostly from researchers of eco-innovation (De Marchi, 2012; Ghisetti et al., 2015; Rauter et al., 2015). Recently, however, academics in the OI field have also dedicated their attention to the ability of open strategies to contribute to sustainable societal transition (Bogers et al., 2020).

### 5.3. Micro-level of open eco-innovation

The microlevel of OEI includes all the internal (organizational) factors that may affect the adoption and implementation of OEI. According to Chesbrough and Bogers (2014), most OI research is conducted at this level and includes determinants related to internal contexts such as the main characteristics of firms, strategic goals, and the specific set of internal resources, capabilities and competences (RCCs) needed to achieve those goals. Also at this level, current literature discusses the rising trend and importance of OEI (Ghisetti et al., 2015; Russo Spina and Di Paola, 2020), its benefits (Albort-Morant et al., 2017; Georg et al., 1992; Melander, 2017; Rauter et al., 2017) and its challenges (Bartlett and Trifilova, 2010; Garcia et al., 2019; Ormazabal et al., 2018; Rizos et al., 2016).

The micro-level comprises cluster 1 and includes the terms eco-innovation, environmental innovation, performance, management, research and development, absorptive capacity, determinants, and knowledge. Here, authors perceive collaboration and cooperation as a

determinant of eco-innovation and the circular economy and as an essential tool to access external resources in order to potentialize the internal R&D of eco-innovative products. This cluster includes two groups of topics; the first searches for scientific evidence that collaboration positively affects the environmental and economic performance of companies, while the second aims to understand what internal RCCs determine the success of OEI adoption and implementation (Kiefer et al., 2019).

In general, studies show that collaboration with external partners can lead to internal efficiencies and resource optimization, which eventually cut costs and add to the firm's competitive advantage (Klewitz et al., 2012). Several authors in recent years have proved that green collaboration has a significant influence on eco-innovation (Aboelmaged and Hashem, 2019) and positively impacts on green patenting activities, as well as the overall innovative capacity of the firm (Moro et al., 2019).

The second group of topics pays closer attention to internal characteristics and RCCs that affect the successful adoption and implementation of OEI. The development of environmental technologies generally requires external knowledge and an additional set of competencies because, in most cases, EI does not form part of the firm's core competencies (Horbach et al., 2012). External knowledge and access to external information can help enterprises to overcome internal constraints and the lack of capabilities for the development of EI and gain an additional competitive advantage in the market (Ghisetti et al., 2015; Triguero et al., 2013). These can be obtained through partnerships with other organizations (De Marchi, 2012a) and a broader spectrum of OEI strategies (Genuchten et al., 2019; Li-Ying et al., 2018).

On the other hand, the successful adoption and implementation of OEI strategies and the ability to take advantage of external resources depend on company characteristics, strategic orientation, and internal RCCs. In the case of organizational traits, current literature suggests that the propensity of a firm to employ OEI may depend on its size (Garcés-Ayerbe et al., 2019), age (Greul et al., 2017), the educational level of employees, and the existence of R&D departments (Solnørdal and Thyholdt, 2017). With respect to strategic goals, studies show the importance of sustainable strategic orientation (Meirun et al., 2020), the type of EI (product, service, process, managerial, business model) (Wong et al., 2020), how radical it is (Lin, 2019), the choice of OI approach (Cano and Londoño-Pineda, 2020), and more specific strategic goals, such as cost reduction (Wong et al., 2020), the enhancement of the green image (Xie et al., 2019), an increase in environmental and economic performance (Ben Amara and Chen, 2020), an increase in production volume and quality (Fabrizi et al., 2018) and the reduction of risks (Pereira et al., 2020). Finally, a new wave of research focuses on firms' internal RCCs which determine the adoption and implementation of OEI. Important determinants are alliance proactiveness (Inigo et al., 2020), network capability (Ben Amara and Chen, 2020), network embeddedness and green social capital (Chen et al., 2019).

In short, we have identified different discussion clusters in the OEI research and explored them through three levels of analysis. While we were able to identify ongoing research in all the clusters and along all the levels of analysis, it became apparent that not all the clusters are developed equally. In the next section of this paper, we draw together the conclusions of our work and propose areas for future research in the area of OEI, based on the research gaps identified.

## 6. Conclusions, future research directions and limitations

This article analyzes the development of research into Open Eco-innovation (OEI) in academic literature, using a systematic approach to the literature review and bibliometric analysis tools, covering the research gaps and limitations of similar previous studies. We also advance an understanding of what OEI is, and what it is not, and contribute to existing theory by identifying the main clusters of discussion topics in OEI research and the thematic gaps that should be

addressed in the future exploration of the topic.

Firstly, we have analyzed the existing systematic literature and bibliometric reviews on the topic of OEI and identified discrepancies among them, as well as their limitations. We have unified the time frames and the selection of the keywords for research into OEI. We have also used both citation databases, WoS and Scopus, simultaneously. These methodological adjustments give a much broader perspective on the distribution of research among geographical zones, academic journals, and research institutions, as well as bringing new authors into the conversation.

Secondly, we have found that OEI is a new line in the literature on eco-innovation that has experienced rapid growth, beginning in 2010. It is not a dead-end research area, as more and more authors are contributing to its exploration and the number of scientific papers is increasing. Our results are consistent and expand the previous literature and bibliometric reviews (Fernández, 2019; Melander, 2017; Pereira et al., 2020; Perl-Vorbach et al., 2014). Despite the scanty literature, OEI has great potential as a research topic, since it requires further development of theoretical understanding and more empirical evidence of its benefits and challenges. On the other hand, practical implementation of OEI strategies helps organizations overcome major barriers to EI and ultimately contributes to sustainable societal transition.

Thirdly, we have explored the existing definitions of OEI and proposed a new one, which helps to delineate the borders of OEI research and explains what OEI is and what it is not. From the theoretical perspective, we have proposed OEI as an umbrella term for all the activities of an organization that strategically utilize access to external resources to potentialize internal EI development or to commercialize internally developed technologies and intellectual property. Thus, collaboration and cooperation activities in EI, the search for external knowledge, the choice of partners, embeddedness in industrial networks, and patenting activities may be viewed and analyzed as parts of a more comprehensive OEI strategy, rather than as separate parts in the process of EI development.

Fourthly, using quantitative bibliometric tools, we have identified the significant clusters of topics in the research on OEI, analyzed them through the prism of a multilevel approach, and proposed a conceptual framework to structure OEI research, based on three levels of analysis and four clusters. We understand that this framework may help to differentiate between various manifestations and perspectives of OEI while showing that all of them form part of the same concept, and believe that this representation can inspire other authors to focus their efforts on the less explored meso-level of OEI research and the relationships between levels.

Finally, we have analyzed and discussed each level and cluster of topics in OEI research. This part of the paper aids understanding of the state of the literature in each research area and stimulates conversation about future research in the field. Further work is needed to empirically prove the benefits of OEI for the environmental and economic performance of organizations, as well as other operational and strategic goals. In addition, future research should identify the main determinants of OEI at each level and in each cluster and how they affect the adoption and success of OEI strategies. As an example, researchers could focus on how company characteristics, strategic goals, and innovation barriers may affect their decision to adopt OEI, the choice of a particular OEI strategy and the selection of partners. Special attention should be paid to the determinants of the meso-level that explore the dynamics of the collaboration process, such as trust among partners, the quality of information exchanged, equity in the distribution of benefits, etc.

Our study has limitations. Firstly, both open innovation and eco-innovation concepts have a considerable number of synonyms. We have tried to include the most commonly used terms in our search string and significantly expanded the selection of previously used keywords in similar studies, although this list is open to further modification. Secondly, we do not address the differences among the sister concepts: “open eco-innovation,” “open circular innovation,” “open social

innovation,” and “open sustainable innovation.” This article considers the literature explicitly concentrating on OEI, yet we believe that research into the other three concepts is very closely related and may help understanding of the full potential of OI for sustainable development. Thirdly, while the general idea of collaboration to decrease the environmental impact of humans has existed for several decades, historical analysis requires different methodologies and approaches and is not covered in this article. Our wish is that in the near future these limitations may be addressed by ourselves and other researchers interested in the concept of OEI.

## Declaration of competing interest

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

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## 6. STUDY 3

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## Open eco-innovation. Aligning cooperation and external knowledge with the levels of eco-innovation radicalness

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## ABSTRACT

The most pressing environmental challenges of our society require radical solutions that would redesign the ways we produce, deliver, and consume goods and services. However, little is known about what actually drives the development of radical eco-innovations. This paper explores the concept of Open Eco-innovation (OEI), an innovation model that leverages external knowledge, resources, and partnerships to enhance internal eco-innovation. Based on the sample of 2 934 Spanish firms from a mixed variety of industries, we demonstrate that an open innovation approach is crucial when firms pursue eco-innovations, particularly when aiming for more radical solutions. Unlike other studies, we show that this importance varies depending on the forms of opening (cooperation vs. sourcing external knowledge), the choice of knowledge partners, and the intended level of eco-innovation radicalness. This paper addresses a gap in understanding the selection of appropriate forms of knowledge sourcing and the choice of knowledge partners for each level of eco-innovation radicalness. Our results also point to a potential mismatch between the importance of open innovation to develop impactful and innovative environmental solutions and a small percentage of organizations adopting this innovation approach.

## 1. Introduction

The intensifying gravity of environmental issues demands our society to search for novel solutions and approaches to the ways we produce, deliver, and consume goods and services, as well as dispose of waste products (Westman et al., 2022; Xin et al., 2022). The changes that reduce the environmental impact of production and consumption activities are called eco-innovations (EIs) (Carrillo-Hermosilla et al., 2010). Based on the degrees of novelty and impact, such innovations are typically divided into incremental and radical (Cui et al., 2022; Kiefer, Carrillo-Hermosilla et al., 2019; Liao et al., 2020), where incremental EIs relate to minor modifications of the original products, services, and processes, and radical EIs involve considerable changes that many times disrupt the traditional business models and the ways to deliver the value to the customer (Boons and Bocken, 2018; Mothe and Nguyen-Thi, 2017). Incremental EIs currently dominate the industry and are essential in the transition of our society toward a more sustainable future (De Marchi et al., 2022; Peyravi and Jakubavičius, 2022). However, the growing consensus suggests that the rapid speed of

environmental degradation and the danger of reaching the point of no return (Steffen et al., 2018) require radical and systemic, rather than incremental solutions (Boons et al., 2013; Brown et al., 2020; Dai et al., 2017).

Despite the importance, little is known about the drivers of radical EIs (Cui et al., 2022) and their possible differences from incremental EIs or other types of innovations (Kiefer, Carrillo-Hermosilla et al., 2019; Smith, 2008). But in general, academic and professional literature suggests that radical EIs tend to be more complex and usually riskier businesswise (Boons and Lüdeke-Freund, 2013; Demirel and Kesidou, 2011). As a result, organizations that strive to implement more radical changes towards sustainability face numerous barriers (Aboelmaged, 2018; Chistov et al., 2023), including the lack of knowledge and capabilities to develop EIs, redirection of limited financial resources towards non-core activities, multiple issues with capture and appropriation of the positive environmental value they provide to customers, and society in general (Ben Amara and Chen, 2020a, 2020b; González-Moreno et al., 2019; Rennings, 2000). One of the possible ways to deal with these challenges is to search for specialized knowledge,

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capabilities, and other resources outside of the firm's boundaries, through various degrees of cooperation with external partners and stakeholders (Hansen and Coenen, 2015). This process of purposeful inflows and outflows of knowledge, resources, and commercialization paths to develop or adopt eco-innovations is increasingly referred to as Open Eco-innovation (OEI) (Acebo et al., 2021; Chistov et al., 2021; Garcia et al., 2019; Ghisetti et al., 2015; Kobarg et al., 2020; Sanni and Verdolini, 2022).

The research into OEI is a rapidly developing stream in the sustainability literature (Kimpimäki et al., 2022; Pereira et al., 2020). Multiple empirical studies confirmed that R&D ties (Liao et al., 2021), close cooperation across the value chain (Levidow, Blind et al., 2016), search and adoption of external knowledge (Mothe and Nguyen-Thi, 2017; Peng and Liu, 2016), and open modes of innovation help to overcome the competence lock-in and decrease the operational risks when firms develop EIs (Chadha, 2011). OEI proved to increase the ability to comply with environmental laws and regulations (Yarahmadi and Higgins, 2012), overcome internal constraints (del Río et al., 2016), reduce financial, operational, and reputational risks (Chadha, 2011), and exploit synergies through efficient use of currently available knowledge and environmental solutions in the industry (Dijkstra, 1982). Consequently, OEI showed a positive relationship with higher eco-innovation performance (Meirun et al., 2020; Mothe and Nguyen-Thi, 2016), higher environmental performance (Ben Amara and Chen, 2020a, 2020b; Rauter et al., 2019), higher economic performance (Pereira et al., 2020; Wang et al., 2019), and enhanced overall competitive advantage of the firm in the market (Klewitz et al., 2012).

A notable limitation of existing studies is the failure to distinguish among various representations of OEI (i.e., degrees of cooperation and knowledge sourcing, different forms of OEI), as well as the degrees of EI radicalness based on its novelty and impact (Brown et al., 2020). To address this research gap, we evaluate the importance of cooperation and external sources of knowledge when organizations pursue various types of EIs based on their levels of radicalness. We contribute to the research into OEI in four ways. We contribute to the research into OEI in four ways. *First*, our study enriches the existing literature by providing empirical support for the transition from the incremental-radical dichotomy of EI radicalness to more complex multi-level approaches that represent multiple degrees of radicalness (Carrillo-Hermosilla et al., 2010; Klewitz and Hansen, 2014). This shift allows for a more nuanced analysis of the relationships between different degrees of EI radicalness and their respective drivers, including the role of OEI strategies. *Second*, we bring new insights to the existing literature by illustrating the distinct effects of various open innovation strategies, such as cooperation or sourcing of external knowledge, on the environmental performance of firms, particularly in terms of EI radicalness. *Third*, we add new empirical evidence to already existing studies that emphasize the importance of inbound open innovation strategy in the form of cooperation and sourcing of external knowledge to drive the development of EI (Ghisetti et al., 2015; Kiefer, Del Río González et al., 2019; Mothe and Nguyen-Thi, 2017). However, we highlight the varying importance of these strategies based on the desired levels of EI radicalness and forms of opening. We empirically prove that cooperation and sourcing knowledge from clients and research institutions are particularly significant for more radical eco-innovations (i.e., eco-effectiveness) while also revealing the particular importance of knowledge from professional associations for incremental eco-innovations (i.e., end-of-pipe solutions) and the relevance of knowledge from suppliers for enhancing energy efficiency (i.e., eco-efficiency). These nuanced findings enrich the literature by providing a more context-specific understanding of the role of open innovation strategies in driving different types of eco-innovations, enabling organizations to better tailor their efforts to achieve desired sustainability outcomes. *Finally*, we reveal the arising OEI paradox – the mismatch between the high importance of the open innovation approach for radical EI and the low number of organizations that adopt OEI strategies.

The following section presents the theoretical background to analyze how different open innovation forms, in particular cooperation and the choice of external knowledge sources, affect the radicalness of EI. The third section explains the applied methodology and data used for empirical tests. Sections four and five summarise and discuss the findings in relation to the current literature. And the last section conveys the limitations of this study and how they might be addressed in the future.

## 2. Theoretical background and hypotheses

### 2.1. Eco-innovation and open eco-innovation

Eco-innovation (EI) can be defined as an innovation that decreases the environmental impacts of production and consumption activities (Carrillo-Hermosilla et al., 2010). Despite more than a decade of research, a precise conceptualization of eco-innovation is still missing (del Río et al., 2016; Pichlak and Szromek, 2022). The diversity in understanding eco-innovation can be attributed to the distinct aspects and characteristics that authors tend to refer to (Kiefer et al., 2017). For instance, the term eco-innovation is used both to relate to the process of developing environmental solutions as well as to solutions themselves (product or service). The changes may be of a technological nature, as well as non-technological (i.e., organizational structures and business models) (Machiba, 2010). They also may focus on consumption patterns or/and on the improvements of methods (production systems) used to create and deliver goods and services (Kulak et al., 2016). Numerous studies to date have proven its crucial role in the transition of our society towards a more sustainable future (Markard et al., 2012), as well as in simultaneously achieving the environmental and business objectives of the firm (Boons and Lüdeke-Freund, 2013). Although promising, EI is not an easy task, and many times is more complex than other types of innovations (Perl-Vorbach et al., 2014) since it is driven by potentially contradicting motivations and faces multiple challenges, including double externality and the proper ways to capture and monetize the value it provides to society (Kiefer, Del Río González et al., 2019; Rennings, 2000).

One of the possible ways to overcome these obstacles is to search for additional help, ideas, and resources outside the boundaries of the firm (Bogers et al., 2020; Perl-Vorbach et al., 2014). Cooperation and the knowledge flows from external stakeholders have been long recognized as crucial drivers of eco-innovation (del Río et al., 2016). Until recently, the research into this relationship was fragmented and dispersed among various management disciplines and multiple definitions (Chistov et al., 2021). Beginning in 2010, this research stream started to consolidate under the term Open Eco-innovation (OEI) and has experienced almost exponential growth since then (Bigliardi and Filippelli, 2022; Kimpimäki et al., 2022; Sanni and Verdolini, 2022).

Chistov et al. (2021), p. 3) define OEI as a “purposive use of inflows and outflows of knowledge, resources, and commercialization paths to develop and/or adopt innovations that improve the environmental performance of the firm.” In other words, the OEI concept represents an umbrella term for activities of the company that relate to the use of external sources of knowledge and cooperation with various stakeholders to develop or adopt eco-innovations (inbound OEI) and possibly their further transfer to other organizations (outbound OEI) (Leitão et al., 2020; Naruetharadhol et al., 2021). OEI pursues two main objectives. The first is to cope with common barriers to EI, such as financial constraints, the lack of knowledge and capabilities, and incompatibility with existing business models and production processes (del Río et al., 2010; González-Moreno et al., 2019). The second is to transfer the new technologies and knowledge to other firms through the commercialization of intellectual property or in the form of positive spillovers (Pakura, 2022; Scarpellini et al., 2012). Such knowledge transfer allows firms to generate additional revenue from their R&D activities through proper patenting and their further commercialization, as well as propagate the new environmental solutions in the

same (or other) industries (Chesbrough and Bogers, 2014; Curley and Salmelin, 2018). Thus, advancing and accelerating the transition of the whole society toward a more sustainable future (Bogers et al., 2020).

The research into OEI seeks to define this concept and understand the determinants of its successful adoption and implementation (Pereira et al., 2020) on various levels of analysis (Garcia et al., 2019). The micro-level explores the individual attitudes of employees and management towards the implementation of OEI and organizational characteristics that may determine its success (i.e., the size and the age of the firm, turnover, the percentage of R&D expenses, etc.) (Avellaneda-Rivera et al., 2020; Hansen and Klewitz, 2012; Pichlak and Szromek, 2021). The meso-level analyses the benefits of cooperation and transfer of knowledge for the environmental and economic performance of the firm (De Marchi, 2012), the proper ways and business models to create and capture the shared value among partners (Chang et al., 2017), the forms of cooperation, the depth and the breadth of such relationships (González-Moreno et al., 2019). The recent studies by Acebo et al. (2021) and De Marchi et al. (2022) examined how the right choice and configuration of partners affect the propensity of organizations to eco-innovate and their environmental performance. Finally, on the macro-level researchers try to understand the possible benefits of OEI on the level of industrial ecosystems (Pichlak and Szromek, 2022), national and world economy, and natural environment (Bigliardi and Filippelli, 2022; Garcia et al., 2019). For instance, recent studies indicate that OEI is crucial for the implementation and support of a circular economy (CE), a system that is designed to minimize environmental and social impacts through the conscious and continuous reuse of materials across the lifecycle of products and services (Köhler et al., 2022).

We situate our research at the meso-level and inbound OEI, investigating how an open approach to innovation (i.e., open innovation) affects the radicalness of eco-innovation in the firm. We build on multiple empirical studies that have already shown the positive relationship between open innovation and eco-innovation and expand them by recognizing that both concepts are complex and multi-dimensional. Therefore, we analyze the openness dimension of innovation as a combination of cooperation activities and the purposeful search and use of external sources of knowledge. We also distinguish between various types of eco-innovation according to their level of radicalness (i.e., degree of novelty and impact of eco-innovation).

## 2.2. Levels of radicalness in eco-innovation

The innovation literature typically distinguishes between incremental and radical types of innovation (Kiefer et al., 2021; Mendes et al., 2021; OECD and Eurostat, 2018; Triguero et al., 2018). Incremental innovations are the ones that modify the accepted processes, products, services, technologies, and business models, while radical innovations change the status quo and aim to entirely rethink and redesign the existing activities and the ways to deliver value to the customer (Adams et al., 2016). According to Dahlin and Behrens (2005), innovations can be considered radical when they are novel, unique, and have an impact on future technology. The classic economic literature suggests that radical innovations are a powerful mechanism to challenge the status quo in industries and markets, level up the ground between large and small firms, and have a dramatic impact on competition and the general survival of the firm (Schumpeter, 1934). The sustainability literature broadens this perspective and conceptualizes EI not as a dichotomy (incremental vs. radical) but rather as a spectrum (Aragón-Correa et al., 2008; Hart, 1995), distinguishing between various types of EI based on the novelty of environmental solutions and their degree of impact on society (Lin et al., 2019).

Throughout the years, various authors put forward frameworks to conceptualize various characteristics and dimensions of eco-innovation. While the terminology may differ among researchers, all frameworks contemplate that there exists a certain hierarchy between types of eco-innovation based on the extent of technological change they require

and their ability to impact the status quo of doing things on a systemic level. For instance, Machiba (2010) classifies eco-innovations based on their targets (process & product, organization institutions) and mechanism (modification, re-design, alternatives, creation). Hansen et al. (2009) proposed a 3D-sustainability innovation cube that focuses on types of innovation (business model, product-service system or technological), effect (ecological, social, and economic), and the life cycle stages (manufacture, use, end-of-life). Adams et al. (2016) propose a three-dimensional framework for eco-innovations based on the innovation focus (technology or people), the level of impact (organizational changes vs. systemic changes), and the extent to which innovation extends across the firm (department level vs. firm level). We base our study on the framework proposed by Carrillo-Hermosilla et al. (2010), which analyses eco-innovation from four dimensions: design dimension, user dimension, product-service dimension, and governance dimension. This is widely accepted framework that accounted for more than 1100 citations at the beginning of the year 2023 and numerous referrals from studies on eco-innovations (Boons et al., 2013; Boons and Lüdeke-Freund, 2013; Inigo and Albareda, 2016; Klewitz and Hansen, 2014).

In particular, we focus on the design dimension of the framework, which suggests that it is possible to distinguish two different rationales for eco-innovation design. The first approach focuses on minimizing the environmental impact of human actions, whereas the second approach involves redesigning human-made systems to reduce environmental impacts. The degree of impact and the nature of technological change play a significant role in determining the appropriate approach. As illustrated in Fig. 1, by combining these factors, we can identify three distinct approaches to eco-innovation: component addition (i.e., end-of-pipe), eco-efficiency, and eco-effectiveness (see Fig. 1). These approaches can also be interpreted as the degrees of eco-innovation radicalness. It is important to mention that rather than a binary option between incremental and radical eco-innovations, framework contemplates radicalness as a scale with various levels. Accordingly, eco-innovations may be considered as less or more radical based on the levels of their impact and the novelty of implemented changes.

On the *component addition* level, organizations focus on finding additional technical components (i.e., "end-of-pipe" technologies) that minimize and repair the negative impacts of production without necessarily addressing the underlying issues that lead to environmental damage in the first place. On this level, the environmental solutions are mostly reactive and appear as a response to changes in environmental regulations and stakeholder pressure (Aragón-Correa and Sharma, 2003). While end-of-pipe eco-innovations can bring significant positive environmental impact, particularly when implemented on a large scale, it is important to recognize that they do not address the underlying causes of environmental issues. This limits their overall environmental impact and highlights the need for more systemic, transformative approaches to eco-innovation. Simply treating the symptoms of

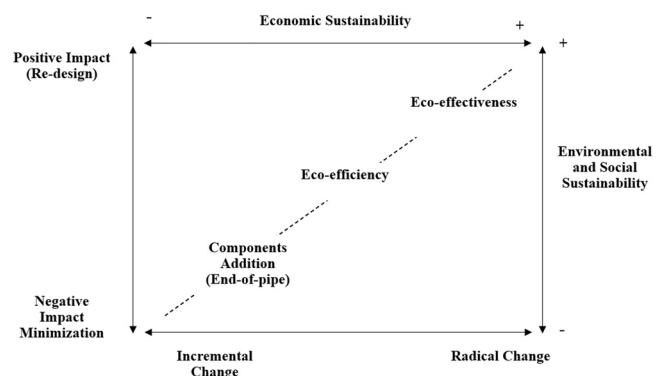


Fig. 1. Design framework for eco-innovation, Source: Adopted from Carrillo-Hermosilla et al. (2010).

environmental problems without addressing their root causes may provide short-term benefits, but it does not lead to long-term sustainability (Triguero et al., 2015).

On the *eco-efficiency* level, organizations focus on increasing the efficiency of production, thus creating more goods and services while decreasing their environmental impact per unit of production as a result of using fewer raw materials and energy. On this level, the aim is to make the existing production systems less destructive through primarily incremental environmental solutions that reduce the firm's costs of managing end-of-pipe mechanisms, increase productivity and efficiency parameters, and parallelly decrease the firm's environmental impact (Lin et al., 2019). While eco-efficient eco-innovations can bring significant positive environmental impact, particularly when implemented on a large scale, it is important to recognize that their impact is limited by a number of factors. Such innovations focus on reducing the environmental impact of existing processes rather than fundamentally transforming them. They are often focused on improving only resource efficiency rather than addressing broader environmental and social issues (Kulak et al., 2016). This narrow focus can limit their overall environmental impact and may not adequately address the root causes of environmental problems (Levidow et al., 2016). Finally, eco-efficient innovations may also have unintended consequences, such as rebound effects, which can offset their positive environmental impact over time (Chenavaz et al., 2021). As such, on the systemic level, their impact is more incremental rather than radical.

Finally, on the level of *eco-effectiveness*, firms seek to completely rethink and redesign the existing ways to produce and deliver products or services and make them biocompatible (compatible with other Earth systems) while still creating commercial added value for customers (Carrillo-Hermosilla et al., 2009; del Río et al., 2021). Such radical changes allow for addressing the root causes of environmental problems rather than simply treating the symptoms (Schaefer et al., 2015). They bring changes to technological systems that are sustainable over the long term rather than providing short-term solutions that may have unintended consequences. By rethinking entire systems, including production processes, supply chains, and consumer behavior, eco-effective systemic eco-innovations can create a more holistic approach to environmental sustainability that addresses social, economic, and environmental issues together (Russo Spina and Di Paola, 2020). While such innovations may require more resources and time to implement, their impact can be far-reaching and transformative, creating lasting benefits for both people and the planet.

In general, EIs are expected to be more radical than other types of innovation because, in most cases, they do not form part of the firm's core activities (Horbach et al., 2013) and may be novel to the organization, as well as to the market and industry (del Río et al., 2015; Kiefer et al., 2019). Such innovations tend to be more complex, require more specialized resources and capabilities, and many times are riskier businesswise (Boons and Lüdeke-Freund, 2013; Demirel and Kesidou, 2011). They also face the issue of double externality, when firms struggle to appropriate the value they provide to society due to involuntary knowledge spillovers and consideration of the Environment as a public good (Gonzalez, 2004; Rennings, 2000). Due to the severity of environmental challenges, the prevailing consensus among scientists and political elites is that end-of-pipe and eco-efficiency solutions are not enough, and our society needs to rethink the current ways of production, delivery, and consumption of products and services completely (Lin et al., 2019; Steffen et al., 2018). As a result, organizations face the double challenge of introducing EIs and ensuring their high degrees of novelty and positive environmental impact.

Despite the increasing interest in the academic literature (Mutira et al., 2022), it is still not clear what drives EIs to be less or more radical (Cui et al., 2022). The available empirical evidence suggests that they appear as a consequence of regulatory and green market pressure, availability of knowledge, resources, and capabilities (Chadha, 2011; Levidow, Blind et al., 2016), environmentally and innovation-oriented

business cultures (Kiefer et al., 2019). Also, such innovations tend to extend beyond the boundaries of one firm and commonly require the understanding and involvement of various stakeholders to achieve higher levels of change (Hansen and Coenen, 2015). According to OI literature, the interaction with external partners represents the flow of knowledge and resources between organizations that can be intentionally managed through various forms of cooperation and intellectual property (Chesbrough, 2003a, 2003b). In this vein, in this study, we aim to investigate how cooperation and knowledge flow from various external partners, such as suppliers, clients, competitors, universities, research centers, consultants, and other intermediaries, contribute to various levels of the radicalness of EI.

### 2.3. Cooperation and radicalness of eco-innovation

The flow of knowledge across the boundaries of the firm may take various forms, i.e., acquisition from other firms through outsourcing, licensing, and consulting; crowdsourcing challenges and competitions; corporate startup incubators and accelerators, mergers, and acquisitions, partnerships with various external stakeholders (Wu, 2022). All of them require some degree of interaction between two or more organizations (Chesbrough, 2003a, 2003b). One of the highest degrees of interaction is cooperation when partners actively participate in joint research and development (R&D) projects (Ryszko, 2016; Tether, 2002).

The literature on EI considers cooperation as one of the antecedents and a crucial driver of EI (Mazzanti and Zoboli, 2009; Rennings and Rammer, 2011), as well as an essential element of OEI strategy (Zhang et al., 2022). Various literature and bibliometric reviews showed that researchers started to analyze this relationship around three decades ago, and the interest only grows over time (Araújo and Franco, 2021; Melander, 2017; Pereira et al., 2020). The early studies suggested that close cooperation with governmental organizations may help to ensure compliance with environmental laws and regulations and minimize the risk of severe financial penalties (Oliver, 1991). And that cooperation with a broad public and interest groups increases the legitimacy (public acceptance) and credibility of firms (Bansal and Roth, 2000). Moreover, close interaction with stakeholders helps to understand better their sustainability concerns and avoid potential conflicts of interest in the future (Gold et al., 2009). The latter research showed that EI is associated with higher levels of uncertainty, complexity, and novelty than general innovations (Horbach et al., 2013; Triguero et al., 2013). In this context, close partnerships with external organizations may help to deal with the lack of in-house knowledge, resources, and capabilities to develop novel environmental solutions (De Marchi, 2012; Horbach, 2008; Petruzzelli et al., 2011), as well as to share the innovation and commercial risks (Aboelimged, 2018). Cooperation may also lead to synergies among partners, which would allow to cut costs of EI R&D (Souto and Rodriguez, 2015), to take advantage of economies of scale (Fabrizi et al., 2018), increase the efficiency and effectiveness of processes (Sánchez-Sellero and Batatineh, 2021), and decrease the time to introduce new green products and services to the market (Melander, 2018; Peñasco et al., 2017).

In summary, cooperation helps organizations to comply with environmental regulations, increase their legitimacy, decrease financial and reputational risks, supplement the internal R&D process with external knowledge and resources, increase efficiencies, and understand their customers better, which all leads to higher competitive advantages in the market (Ghissetti et al., 2015; Triguero et al., 2013). Overall, different forms of cooperation showed a direct positive effect (Calza et al., 2021) or positive moderation and mediation effects on the environmental performance of firms (Martinez-Sanchez et al., 2009). Multiple empirical studies proved that it is indeed an essential driver of eco-innovation (Arranz et al., 2019; De Marchi, 2012; Horbach, 2016). In fact, the research even suggests that EI is particularly dependent on cooperation and external sources of knowledge, in contrast to general

innovation (De Marchi, 2012; Higgins and Yarahmadi, 2014; Horbach, 2008).

Much less is known about the role of cooperation on different levels of EI radicalness. Studies show that radical and systemic types of EIs are more complex than incremental EIs and have higher requirements in terms of funding and internal innovation capabilities (Kiefer et al., 2018). They also often require changes in the supply chain and business models, thus making cooperation with various stakeholders inevitable (Cainelli et al., 2015; De Marchi, 2012; Kanda et al., 2018). According to Brown et al. (2020), incremental EI allows organizations to start small and develop the necessary capabilities, but radical EI will require more complex and costly collaborations to move toward new systems of production and consumption. Cooperation and OI strategies showed the potential to strengthen the propensity of the firm to generate radical EI (Pichlak and Szromek, 2021). The prior research also revealed that cooperation is equally important for radical EIs in small firms that are usually constrained in resources (Halme and Korpela, 2014; Wagner and Llerena, 2011), as well as large firms that require public-private partnerships, legitimacy, and appropriate regulations to diffuse large-scale environmental technology systems (Kanda et al., 2016).

In summary, we can conclude that while cooperation brings additional levels of complexity and there exist a certain hesitance to partner up to develop EIs, it affects positively incremental EIs, and is especially important for radical EIs (Inigo et al., 2020; Mothe and Nguyen-Thi, 2016). Accordingly, in this study, we hypothesize that cooperation will exhibit a positive relationship at each level of EI radicalness (i.e., components addition, eco-efficiency, and eco-effectiveness) and will be especially important at the eco-effectiveness level. Therefore, we formulate the following hypotheses:

**H1.** . Cooperation is positively related to eco-innovation at all levels of radicalness - (a) Component Addition; (b) Eco-efficiency; (c) Eco-effectiveness.

**H2.** . Cooperation is particularly important for higher levels of eco-innovation radicalness (i.e., eco-effectiveness level).

#### 2.4. External knowledge sources and radicalness of eco-innovation

The original research into OEI treated cooperation as an independent self-containing variable and tried to understand the general effect of collaboration on the environmental and business performance of the firm (Kennedy et al., 2017). However, recent advancements show that it is a complex phenomenon that depends on a broad array of specific determinants (Chistov et al., 2021; Garcia et al., 2019). OEI literature suggests that behind cooperation, there is a flow of knowledge and resources between two or more organizations that should support their individual or mutual business objectives (Chesbrough, 2003a, 2003b). According to the knowledge-based view, knowledge is one of the crucial resources for any organization and should be properly managed (Grant, 1996). Therefore, companies have to develop critical capabilities to search and acquire complementary knowledge outside of their boundaries (i.e., knowledge scouting), delineate the proper knowledge sources, establish proper ways and protocols to transfer the knowledge (i.e., knowledge sharing), and properly integrate it into the existing organizational processes (i.e., absorptive capacity) (Albort-Morant et al., 2018; Song et al., 2021).

One of the rising topics in the OEI literature is the matter of proper selection of knowledge sources (De Marchi et al., 2022, p. 202; Kobarg et al., 2020; Santos et al., 2021; Solesvik, 2018). The classic innovation literature posits that the production of new ideas stems from a function that reconfigures old ideas, creating a combinatoric feedback process where knowledge builds upon itself, potentially impacting economic growth (Weitzman, 1998). Studies show that radical innovations rely heavily on a firm's ability to consolidate an abundance of potential new ideas into a stable form of a product or service; however, the open

innovation approach recognizes that the best knowledge and ideas are not confined within a single firm's boundaries (H. Chesbrough and Bogers, 2014). Consequently, organizations are forced to match their internal skills with distinctive, complementary, and sometimes unique competencies of external organizations (Ben Arfi et al., 2018; Caloghirou et al., 2004).

However, tapping into external sources of knowledge and choosing the right knowledge partner is not an easy task. *First*, case studies show that, in practice, partners and their attitudes have the power to "make or break" all the collaboration efforts of the firm (Pujari et al., 2003; Rizzi et al., 2013). *Second*, from a management perspective, the search for external knowledge and collaboration with stakeholders may entail the reallocation of internal personnel, time, and resources from the core activities of the firm, thus jeopardizing its business performance (Horbach et al., 2013; Klewitz and Hansen, 2014; Petruzzelli et al., 2011). *Third*, managers often have to make decisions under conditions of uncertainty since they rarely have full information about their partners and struggle to predict the real positive affect of a combination of knowledge and expertise among firms (Fleming, 2001; Rosenberg, 1996; Solesvik, 2018). *Fourth*, according to innovation search theory, there exists a point when the amount and complexity of external knowledge become too hard to handle, and organizations may start making mistakes (Koput, 1997; Stucki and Woerter, 2022). Also, an excessively broad network of external partners and sources of knowledge brings additional complexity to the open innovation structures that can have more negative effects on eco-innovation than positive (Hermann et al., 2016). *Finally*, recent empirical research suggests that specific sustainability objectives of the firm may require knowledge from specific partners or a combination of partners. And that the mismatch between them may lead to lower efficiency and effectiveness of OEI endeavors (De Marchi et al., 2022; Kobarg et al., 2020). In summary, the choice of external knowledge sources, their combination, the depth, and the breadth of collaboration are of strategic importance and has to be tailored to the particular needs and goals of the firm (Acebo et al., 2021; Sanchez-Henriquez and Pavez, 2021).

The existing research explores various possible approaches and dimensions to understand the selection process of knowledge sources and partners for OEI. Several studies reviewed the potential optimal number of external knowledge sources and partners in the network (the breadth of collaboration) and how close this partnership should be (the depth of collaboration) (Ghissetti et al., 2015; Juntunen et al., 2019). Some studies explore the advantages and disadvantages of collaboration with a specific type of partner in isolation, including suppliers (Melander and Pazirandeh, 2019; Potter and Graham, 2019), universities (Song et al., 2020), and competitors (Li et al., 2021), or the impact of a particular group of partners, such as value chain partners (suppliers and customers) (Ocicka et al., 2022), or intermediaries (government agencies, consultants, public universities and research centers) (Al-Hanakta et al., 2021; Kanda et al., 2020). Other studies are able to leverage the available data and compare the impacts among the partners on environmental performance in the same context and using the same data (Kobarg et al., 2020; Sanchez-Henriquez and Pavez, 2021). Finally, while the conventional perspective on the matter suggested that due to the systemic nature of EI, it requires knowledge from a broad array of partners and stakeholders that is complimentary (Horbach et al., 2012) (suggesting that all the partners may be equally significant), Acebo et al. (2021) and De Marchi et al. (2022) found that the knowledge from various sources should also be compatible and that the combination of specific knowledge partners in the open innovation network also matters and may lead to positive or negative effects on environmental and business performance of the firm, being particularly relevant for more radical eco-innovations (Shou et al., 2018).

The OEI literature, however, does not yet provide clear guidance for the selection of knowledge sources according to the levels of EI radicalness. The scarce empirical evidence suggests that due to considerable business risks, difficulty to manage, and inherent uncertainties, radical

EIs may require cooperation with public clients that could share the burden of innovation risks, establish favorable conditions, provide a first-hand perspective on governmental environmental strategies and regulations, and connect the firm with other stakeholders (Lenderink et al., 2022). Close cooperation and sourcing knowledge from suppliers draw important attention in OEI literature (Chistov et al., 2021), but their association with radical EIs is controversial. While some studies show a positive relationship with both incremental and radical EIs (Roscoe et al., 2016; Zhang et al., 2020), others point out that the overestimated trust in suppliers can have a negative impact on radical EIs (Zhao et al., 2020). Additionally, universities and research centers are also considered as crucial knowledge partners and allow organizations to upgrade internal technological capabilities as well as decrease the inherent risks of eco-innovation (Scarpellini et al., 2017). These sources of knowledge are especially beneficial for eco-product innovation (Triguero et al., 2013) and essential for radical EIs (del Río et al., 2015).

We extend this line of research and explore the importance of sources of external knowledge on various levels of EI radicalness based on their novelty and impact. In line with the previous research, we anticipate a generally positive relationship. However, we also expect that the importance of particular sources of knowledge may not be consistent throughout all the levels of EI radicalness. Thus, we pose our next hypotheses:

**H3.** *External knowledge sources are positively related to the different levels of eco-innovation radicalness— (a) End-of-pipe, (b) Eco-efficiency, (c) Eco-effectiveness.*

**H4.** *The importance of the different external knowledge sources varies according to the level of the radicalness of eco-innovation.*

### 3. Methodology

#### 3.1. Sample

In order to test our hypotheses, we use the data from the Spanish Technological Innovation Panel (PITEC), a survey prepared and distributed by the National Institute of Statistics in Spain (INE) and the Spanish Foundation for Science and Technology (FECYT). It has a goal of evaluating technological activities in Spanish companies. The database started to collect information in 2003 and offers more than 460 variables based on answers from more than 12,000 companies distributed among different sectors and locations in Spain. PITEC is closely based on the Community Innovation Survey (CIS) – a survey on the innovativeness of sectors that provides information about firms' characteristics, the types of innovation they pursue, and various aspects of their R&D development. This survey is one of the most used sources of empirical data in the literature on EI and open innovation (De Marchi, 2012; del Río et al., 2016; Ghisetti et al., 2015; Horbach et al., 2012). The limitation of this database is that the companies access and report their innovation activities independently and that the results may be subjective (Saez-Martinez et al., 2016).

The PITEC data set is an unbalanced panel and offers the possibility to track the same sample of organizations at different points in time. There exist several approaches to choosing the period for investigation. First, to analyze the data from several consecutive years, which is particularly useful when authors introduce the lagged explanatory variables (Acebo et al., 2021; Hernández-Trasobares and Murillo-Luna, 2020). The second is to choose only one year for observation since the changing nature of the sample and questionnaire in PITEC may pose challenges for inter-temporal analyses. In this study, logistic regression is employed as the primary statistical model due to the nature of the dependent variables. However, using this method with unbalanced panel data can introduce various challenges, such as biased estimates, efficiency loss, model misspecification, and difficulties managing

missing data. Consequently, we chose to analyze variables from a single observation period for our primary models. We utilized the 2016 data, which is the latest available survey published by the National Statistics Institute of Spain. The original 2015–2016 dataset contained observations for 12,849 firms. We excluded firms that experienced sudden changes in employment due to mergers, acquisitions, or high labor turnover (Acebo et al., 2021; González-Pernía et al., 2015) and firms that did not report on their eco-innovation activities. The resulting sample is composed of 2934 firms.

#### 3.2. Measurement of Variables

##### 3.2.1. Dependent variables

The main dependent variables of this research represent the objectives of the firm to reach a particular level of eco-innovation radicalness. PITEC survey follows the Oslo Manual guidelines and defines innovation as “a new or improved product, or process (or a combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)” (OECD and Eurostat, 2018, p.20). As a proxy to the *component's addition* level, we use the variable that shows if the objective of innovation was to comply with the environmental regulations since they traditionally favor the end-of-pipe solutions and impose minimal standards, that balance between the environmental impact of the firm and its profitability (Frondel et al., 2007). To analyze the level of *eco-efficiency*, we originally created a new variable that combined innovation goals that focused on the decrease in material and energy use per unit of production. However, later we also tested models where those two goals were separate. We concluded that while conceptually they represent the general efficiency of the production process, in practice, they tend to require different sets of expertise and different combination of knowledge sources. As a result, we left both of them separated in the model. Finally, we have created a new variable to represent the level of *eco-effectiveness* that combines two variables (i.e., the interaction between these two variables): the variable measuring that the firm has “innovation goals that focus on decreasing the general environmental impact of the firm” and the variable regarding the innovation goals “to develop technologies that are new to the market.” All the dependent variables are dichotomic, and most of them (except the variable on eco-effectiveness) take the value (1) if the innovation objective has high relevance for the firm, and zero (0), if it is of low relevance. In the case of eco-effectiveness, the variable takes the value one (1) if the decrease of the environmental impact was an innovation priority of the firm and if it used technologies that were not currently available in the market, and it took the value of zero (0) if the objective to decrease the environmental impact was of low importance or the technology used was not new to the market. In the context of our research, value (1) indicates the intention of the firm to pursue a particular level of EI radicalness.

##### 3.2.2. Independent variables

The explanatory variables in our study represent cooperation and the importance of various sources of external knowledge for organizations during the innovation process. This is an example of inbound open innovation when the knowledge is sourced outside the boundaries of an organization (Chesbrough and Bogers, 2014). The database provides information on the relevance of particular stakeholders as sources of external knowledge. The variables are dichotomic. The cooperation variable takes the value (1) if the organization actively cooperated with external partners during the innovation process and (0) if an organization didn't cooperate with external partners. Variables for external knowledge sources take the value one (1) if a particular knowledge source was considered relevant and zero (0) in cases where a particular external knowledge source was irrelevant. This set of variables includes sourcing knowledge from suppliers, clients, competitors, consultants, universities, research centers (with the distinction between public and private), and professional associations.

### 3.2.3. Control variables

In order to control for factors that also might have an impact on the radicalness of eco-innovation, we included a set of variables that previously proved to have such an impact, considering: the Age of the firm that shows its general experience in the market; Size of the firm: *Small* (less than 50 employees), *Medium-sized* (51–250 employees), and *Large* (more than 250 employees). Moreover, *Export-orientation* of the firm, since the international regulations tend to inspire firms to strive for higher levels of eco-innovation (González-Pernía & Peña-Legazkue, 2015; Triguero et al., 2018). We also included a list of sectors that were previously explored in the literature, such as the agriculture sector (Silvestri et al., 2022), food sector (Triguero et al., 2018), hospitality sector (Aboelmaged, 2018), and manufacturing sector (Acebo et al., 2021).

### 3.3. Statistical Method

To test our hypotheses, we use binomial logistic regression. We chose this method based on several reasons. First, is due to the dichotomous nature of our variables. Second, while our data allows constructing the dependent variable of EI radicalness as a scale variable, we did not opt for this option since that would indicate the hierarchical relationship between the three levels of radicalness. In reality, organizations may simultaneously pursue various degrees of EI radicalness (i.e., *components addition*, *eco-efficiency* and *eco-effectiveness*). We also wanted to compare and draw conclusions from comparing the levels among each other. Our models and the statistical method allowed us to take into consideration these concerns.

In contrast to the ordinary least squares regression, logistic regression estimates a probability of a particular event to happen. In our study, this event is reaching various levels of eco-innovation radicalness. We can represent the relationship between the binary dependent variable (levels of eco-innovation radicalness) with multiple independent variables (i.e., cooperation, various sources of knowledge) with the following formula:  $\text{Log}(\text{odds}) = \text{Log}(p / (1 - p)) = \beta_0 + \beta_1x_1 + \beta_2x_2 + \beta_3x_3 + \beta_4x_4$ , where  $\text{log}(\text{odds})$  is the natural logarithm of the likelihood of a firm to pursue one of the levels of eco-innovation radicalness (value one (1)) and zero (0) otherwise (Greene, 2003; Hosmer and Lemeshow, 2004). Here  $p$  is the probability of the dependent variable being equal to 1 given the values of the independent variables  $x_1, x_2, x_3$ , and  $x_4$ ,  $\beta_0$  (beta zero) is the intercept, which represents the  $\text{log}(\text{odds})$  when all independent variables are equal to 0, and  $\beta_1, \beta_2, \beta_3$ , and  $\beta_n$  are the coefficients for the independent variables  $x_1, x_2, x_3$ , and  $x_n$ , respectively, which represent the change in  $\text{log}(\text{odds})$  for a one-unit increase in each independent variable, holding all other independent variables constant (i.e., cooperation; sources of external knowledge) and control variables (i.e., age, size, export orientation).

In this study, we employed Nagelkerke's R-square as a measure to assess the goodness of fit for our logistic regression model. It is crucial to note that Nagelkerke's R-square, also known as pseudo-R-squared, represents the proportional reduction in the absolute value of the log-likelihood measure, rather than the amount of variance accounted for, as in linear regression analysis. It ranges from 0 to 1, with values closer to 1 indicating a better fit of the model. We use the SPSS statistical package to test our models.

#### 3.3.1. Robustness check

To evaluate the structural validity of the proposed models, we perform the robustness test. The model is considered robust when the “core” regression coefficient estimates behave similarly when the regression parameters are modified by adding or removing regressors (Lu and White, 2014). In this study, we first perform the sensitivity test by removing control variables, thus eliminating their possible influence on the models. Another way of testing robustness is by switching dependent and independent variables with very similar substitutes. The characteristics of our data allow us to use the lagged variables for

cooperation and external sources of knowledge from the 2015 version of the PITEC survey. The use of lagged explanatory variables is one of the common ways to address the issue of delays between the introduction of new organizational practices and their impact (González-Pernía et al., 2015). Consequently, in our robustness models, the dependent variables are from 2016, and the independent variables are from 2015 (the lagged variables), and we do not include the control variables. We expect that the importance of cooperation and external sources of knowledge for the firm does not dramatically change in a matter of one year (from 2015 to 2016) and that they will excerpt a similar relationship with different levels of EI radicalness.

## 4. Results

### 4.1. Multicollinearity and quality of the models

First, we examined the quality of our main models and the variables that were included in the models. The variance inflation factors (VIF) of all the variables fell within an acceptable range (i.e., under 5.0), therefore, we discarded the possible issues related to multicollinearity (see Table 2). The omnibus test for all our models (both main and robustness models) showed an acceptable significance of 0.00 (less than 0.05), indicating that they outperformed the null models. Furthermore, we evaluated their “goodness of fit” based on Nagelkerke's pseudo-R2. Unlike the ordinary least square-R2, it does not represent a proportion of explained variance, but the improvement in the likelihood of the model over the null model and can be compared to other pseudo-R2 derived from the same data, using the same set of explanatory variables, or predicting the same outcome (Hemmert et al., 2018). In the case of our main models (see Table 3), the model for eco-effectiveness showed the best results (18%), followed by component addition (17.9%), energy efficiency (16.3%), and material efficiency (15.7%).

### 4.2. Descriptive analyses

Descriptive analyses carried out included a frequency analysis and a correlation analysis (Table 1 and Table 2). The frequency analysis showed a quite balanced representation of small (37.9%), medium (37.1%), and large (25.1%) firms in our sample made by 2 934 observations. We noticed a significant positive correlation between the small firms and eco-innovations that focus on compliance and eco-efficiency (i.e., less radical eco-innovations) and a negative significant

**Table 1**  
Descriptive Analysis I: Frequency Analysis.

	Frequency	Valid Percent
Component Addition	1653	56.3%
Material Efficiency	1271	43.3%
Energy Efficiency	1324	45.1%
Eco-effectiveness	973	33.2%
Cooperation	1528	52.1%
Small firms	1111	37.9%
Medium-sized firms	1088	37.1%
Large firms	735	25.1%
Firm Market: National	2793	95.2%
Firm Market: International	2116	72.1%
Belonging to a group of companies	1604	54.7%
Introduction of products that are new to the firm	2294	78.2%
Introduction of products that are new to the market	1607	54.8%
Agriculture Sector	18	0.6%
Food Sector	241	8.2%
Hospitality Sector	12	0.4%
Manufacturing Sector	844	28.8%
<b>Total number of respondents</b>	<b>2934</b>	<b>100%</b>

Source: Authors' elaboration.

**Table 2**  
Descriptive Analysis II: Descriptive Statistics and Correlation Matrix.

	Mean	VIF	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Component Addition	2.4	1.699																					
Material Efficiency	2.71	2.741	0.494**																				
Energy Efficiency	2.67	3.001	0.556**	0.789**																			
Eco-effectiveness	0.33	1.368	-0.452**	-0.304**	-0.351**																		
Cooperation	0.52	1.222	-0.176**	-0.126**	-0.157**	0.232**																	
Suppliers	0.66	1.209	-0.220**	-0.228**	-0.241**	0.126**	0.139**																
Private Clients	0.65	1.469	-0.236**	-0.220**	-0.212**	0.187**	0.156**	0.263**															
Public Clients	0.34	1.379	-0.155**	-0.140**	-0.135**	0.141**	0.143**	0.176**	0.439**														
Competitors	0.48	1.308	-0.187**	-0.192**	-0.168**	0.108**	0.140**	0.258**	0.356**	0.312**													
Consultants	0.35	1.420	-0.209**	-0.182**	-0.193**	0.181**	0.240**	0.257**	0.220**	0.266**	0.328**												
Universities	0.33	1.853	-0.188**	-0.171**	-0.204**	0.233**	0.322**	0.136**	0.180**	0.258**	0.203**	0.369**											
Public Research Centers	0.28	2.217	-0.203**	-0.176**	-0.203**	0.262**	0.313**	0.166**	0.205**	0.271**	0.219**	0.381**	0.630**										
Private Research Centers	0.32	2.007	-0.226**	-0.201**	-0.232**	0.261**	0.330**	0.195**	0.238**	0.251**	0.228**	0.411**	0.548**	0.657**									
Professional Associations	0.35	1.305	-0.231**	-0.181**	-0.207**	0.179**	0.180**	0.226**	0.243**	0.287**	0.270**	0.329**	0.312**	0.323**	0.318**								
Age	40.75	1.107	-0.086**	-0.061**	-0.074**	0.043*	0.047*	0.040*	-0.019	-0.025	0.009	0.041*	-0.013	-0.001	0.010	0.018							
Small firm	0.38	1.353	0.118**	0.118**	0.120**	-0.102**	-0.143**	-0.124**	0.007	-0.035	-0.064**	-0.103**	-0.083**	-0.097**	-0.096**	-0.065**	-0.253**						
Large Firms	0.25	1.368	-0.062**	-0.069**	-0.075**	0.102**	0.139**	0.078**	-0.036*	0.051**	0.037*	0.110**	0.082**	0.073**	0.064**	0.053**	0.228**	-0.451**					
Export Orientation	0.72	1.161	-0.132**	-0.147**	-0.119**	0.094**	0.027	0.018	0.177**	0.028	0.060**	0.041*	0.058**	0.063**	0.084**	0.007	0.079**	-0.071**	-0.114**				
Agriculture Sector	0.01	1.016	0.021	0.021	0.027	-0.009	0.005	-0.045*	-0.006	-0.001	0.003	0.024	0.056**	0.067**	0.058**	0.025	-0.021	0.011	-0.025	-0.039*			
Food Sector	0.08	1.076	-0.058**	-0.035	-0.060**	-0.021	-0.006	0.023	0.011	-0.029	0.012	0.041*	0.015	0.041*	0.025	0.045*	0.007	-0.103**	0.073**	0.039*	-0.024		
Hospitality Sector	0.00	1.024	0.036	0.017	0.029	-0.034	-0.003	-0.010	-0.031	-0.023	-0.008	0.008	-0.033	-0.017	-0.033	-0.002	0.007	-0.050**	0.099**	-0.103**	-0.005	-0.019	
Manufacturing Sector	0.29	1.186	-0.080**	-0.133**	-0.106**	0.023	-0.066**	0.031	0.095**	-0.029	0.003	-0.066**	-0.104**	-0.076**	-0.041*	-0.094**	0.038*	0.016	-0.138**	0.242**	-0.050**	-0.190**	

N = 2 934 observations

\*p < 0.01; \*\*p < 0.05; \*\*\*p = 0.00

Source: Authors' elaboration.

**Table 3**  
Main Models.

		Component Addition (Exp (β))	Eco-efficiency (Exp (β))		Eco-effectiveness (Exp (β))
			Materials	Energy	
Knowledge Sources	Cooperation	1.309 **	1.059	1.231 **	1.803 ***
	Suppliers	1.473 ***	1.662 ***	1.788 ***	1.161
	Private Clients	1.443 ***	1.351 **	1.241 **	1.706 ***
	Public Clients	1.179 *	1.100	1.003	0.990
	Competitors	1.189 *	1.326 **	1.205 **	0.889
	Consultants	1.143	1.196 *	1.112	1.104
	Universities	1.214 *	1.183	1.337 **	1.224 *
	Public Research Centers	1.192	1.116	1.046	1.536 **
	Private Research Centers	1.250 *	1.201	1.352 **	1.414 **
	Professional Associations	1.610 ***	1.424 ***	1.534 ***	1.325 **
Control Variables	Age	1.004 **	1.000	1.002	1.001
	Small firms	0.815 **	0.800 **	0.860	0.869
	Large Firms	1.063	1.237 **	1.208 *	1.443 **
	Export Orientation	1.421 ***	1.348 **	1.297 **	1.369 **
	Agriculture Sector	0.820	1.015	0.863	0.606
	Food Sector	1.700 **	1.274	1.562 **	0.701 **
	Hospitality Sector	0.374	0.607	0.317	0.192
	Manufacturing Sector	1.593 ***	1.883 ***	1.666 ***	1.164
	Constant	0.244 ***	0.171 ***	0.168 ***	0.105 ***
	R2	17.9%***	15.7%***	16.3%***	18%***
N	2934	2934	2934	2934	

N = 2 934 observations

\*p < 0.01; \*\*p < 0.05; \*\*\*p = 0.00

Source: Authors' elaboration.

correlation with more radical eco-innovations. Interestingly, the large firms demonstrated a completely reverse dynamic. These results are in line with previous studies that showed that due to liabilities of newness and smallness (Wagner and Llerena, 2011), and the lack of resources, radical EIs might be out of reach for small firms (Lacy and Rutqvist, 2015), and they engage only in lower levels of EI radicalness (i.e., components addition and eco-efficiency) (Kiefer et al., 2021).

Regarding age, the mean age in the sample was 41 years old. Less than 0.02% of organizations were younger than ten years old. Thus, the results of our investigation represent the dynamics in mature firms rather than new ventures. Moreover, we observe a negative correlation between age and lower-impact environmental objectives and a positive significant correlation with higher-impact environmental objectives. In summary, more radical EIs were positively associated with larger and older firms. In contrast, the less radical types of eco-innovations (i.e., those including objectives of environmental compliance and eco-efficiency) were positively associated with younger and smaller firms. The existing literature does not provide a definitive perspective on the influence of a firm's age on radical EI, however, there exist some indications that due to high complexity, it requires an accumulation of internal innovation capacity that normally happens with time (del Río et al., 2015).

As far as the industry is concerned, we find that manufacturing firms constituted 28.8% of our sample, and the rest of it was distributed among other industries, including agriculture, food production, pharmaceuticals, energy production and networks, hospitality, IT, and others. 54.7% of firms belong to a group of companies, and 7.3% of them are located in industrial parks.

With regard to export orientation, more than 95% of companies focus on local and national markets, but there is also a considerable number (72.1%) that target international markets. We found that the export orientation of firms was positively correlated with more radical eco-innovations and negatively correlated with less radical eco-innovations (i.e., firms pursue other environmental objectives, such as compliance and efficiency). These results coincide with the analysis performed by Torrecillas and Fernández (2022), which also used the PITEC data.

On the other hand, we found that there exists a difference in the percentage of firms according to the radicalness of eco-innovation.

While more than half of the firms strive to comply with environmental regulations (56.3%) (i.e., end-of-pipe solutions), less than half of them innovate to increase their material (43.3%) and energy efficiency (45.1%) (i.e., eco-efficiency level), and only 33.2% pursue more radical EI (i.e., eco-effectiveness; new-to-the-market). This is also consistent with previous studies that suggest that incremental environmental solutions are easier to implement than more radical ones (Carrillo-Hermosilla et al., 2009) Finally, only half of the firms in the sample (52.1%) reported active cooperation with external partners during the eco-innovation process, and much less whenever they pursued more radical eco-innovation objectives: compliance/end-of-pipe (33%), material efficiency (25%), energy efficiency (27%) and eco-effectiveness (i.e., radical eco-innovation) (23%).

#### 4.3. Main models analysis

Table 3 presents the results of the analysis of the main models and hypotheses testing, in particular, the impact of cooperation and various external knowledge sources on different types of eco-innovation (i.e., different levels of eco-innovation radicalness). Our results show (see Table 3) that firms that cooperated with external partners during the innovation process were 31% more likely to pursue the goal of compliance with environmental regulations (i.e., components addition) (i.e.,  $Exp(\beta) = 1.309$ ,  $p < 0.01$ ), 23% more likely to focus on energy efficiency (i.e.,  $Exp(\beta) = 1.231$ ,  $p < 0.01$ ), and 80% more likely to pursue more radical eco-innovations (i.e.,  $Exp(\beta) = 1.803$ ,  $p = 0.00$ ). We did not get any significant results for the case of material efficiency.

Regarding the external sources of knowledge, firms that consider the information from suppliers important are 47% more likely to be pursuing the goal of compliance with environmental regulations (i.e.,  $Exp(\beta) = 1.473$ ,  $p = 0.00$ ), 66% - material efficiency (i.e.,  $Exp(\beta) = 1.662$ ,  $p = 0.00$ ), and 79% - energy efficiency (i.e.,  $Exp(\beta) = 1.788$ ,  $p = 0.00$ ). However, we did not get any significant results for the eco-effectiveness level. Companies that reported the high importance of knowledge from private clients were 44% more likely to focus on compliance with regulations (i.e.,  $Exp(\beta) = 1.443$ ,  $p = 0.00$ ), 35% on material efficiency (i.e.,  $Exp(\beta) = 1.351$ ,  $p < 0.01$ ), 24% on energy efficiency (i.e.,  $Exp(\beta) = 1.241$ ,  $p < 0.01$ ), and 71% on more radical eco-innovations (i.e.,  $Exp(\beta) = 1.706$ ,  $p < 0.01$ ). Both public (i.e.,

**Table 4**  
Robustness and Sensitivity Test.

		Component Addition ( $Exp(\beta)$ )	Eco-efficiency ( $Exp(\beta)$ )		Eco-effectiveness ( $Exp(\beta)$ )
			Materials	Energy	
Knowledge Sources	Cooperation	1.594***	1.219**	1.414***	2.186***
	Suppliers	1.467***	1.660***	1.731***	1.202*
	Private Clients	1.506***	1.312**	1.231**	1.439**
	Public Clients	0.956	1.319**	1.150	0.871
	Competitors	1.095	1.142	1.157	1.056
	Consultants	1.221*	1.172	1.109	1.179
	Universities	1.107	0.816	0.879	1.091
	Public Research Centers	1.115	1.507***	1.600***	1.426**
	Private Research Centers	1.486***	1.065	1.110	1.493***
	Professional Associations	-	-	-	-
	R2	10.1%***	8.3%***	9.3%***	12.5%***
	N	2934	2934	2934	2934

N = 2 934 observations

\*p < 0.01; \*\*p < 0.05; \*\*\*p = 0.00

Source: Authors' elaboration.

**Table 5**  
Relationship of cooperation and external sources of knowledge with levels of eco-innovation radicalness.

		Component Addition	Eco-efficiency		Eco-effectiveness
			Materials	Energy	
Knowledge Sources	Cooperation	X		X	XX
	Suppliers	X	X	XX	
	Private Clients	X	X	X	XX
	Public Clients				
	Competitors				
	Consultants				
	Universities				
	Public Research Centers				XX
	Private Research Centers	X			XX
	Professional Associations	XX	X	X	X

Source: Authors' elaboration.

$Exp(\beta) = 1.536$ ,  $p < 0.01$ ) and private (i.e.,  $Exp(\beta) = 1.414$ ,  $p < 0.01$ ) research centers proved to be crucial for the highest level of eco-innovation radicalness (i.e., eco-effectiveness), and private research centers are also relevant in lower levels of eco-innovation radicalness (component addition [ $Exp(\beta) = 1.250$ ,  $p < 0.05$ ] and energy efficiency [ $Exp(\beta) = 1.352$ ,  $p < 0.01$ ]). Finally, the knowledge from professional associations proved to be essential for all the types of eco-innovations, in particular regarding environmental compliance (i.e., component addition) (i.e.,  $Exp(\beta) = 1.610$ ,  $p = 0.00$ ), materials (i.e.,  $Exp(\beta) = 1.424$ ,  $p = 0.00$ ) and energy (i.e.,  $Exp(\beta) = 1.534$ ,  $p = 0.00$ ) efficiency.

Regarding the control variables (Table 2), we observed that small firms (less than 50 employees) were less likely to focus on compliance (i.e.,  $Exp(\beta) = 0.815$ ,  $p < 0.01$ ) and materials efficiency (i.e.,  $Exp(\beta) = 0.800$ ,  $p < 0.01$ ) (contrary to the results of correlation analysis), while large firms tended to pursue materials efficiency (i.e.,  $Exp(\beta) = 1.237$ ,  $p < 0.01$ ), energy efficiency (i.e.,  $Exp(\beta) = 1.208$ ,  $p < 0.05$ ), and radical eco-innovation (i.e.,  $Exp(\beta) = 1.443$ ,  $p < 0.01$ ). The export orientation of the firm performed similarly to correlation analysis and showed that firms which focus on international markets were 42% more likely to focus on compliance (i.e.,  $Exp(\beta) = 1.421$ ,  $p = 0.00$ ), 34% on material efficiency (i.e.,  $Exp(\beta) = 1.348$ ,  $p < 0.01$ ), 30% on energy efficiency (i.e.,  $Exp(\beta) = 1.297$ ,  $p < 0.01$ ), and 37% on radical eco-innovations (i.e.,  $Exp(\beta) = 1.369$ ,  $p < 0.01$ ). Finally, the results revealed that the importance of different types of eco-innovations might vary based on the industry. For instance, firms from the manufacturing industry were 59% more likely to focus on compliance (i.e.,  $Exp(\beta) = 1.593$ ,  $p = 0.00$ ), 88% on decreasing the materials use (i.e.,  $Exp(\beta) = 1.883$ ,  $p = 0.00$ ), and 67% on decreasing the energy consumption (i.e.,  $Exp(\beta) = 1.666$ ,  $p = 0.00$ ). The firms

from the food industry were 70% more likely to search for new solutions to comply with regulations (i.e.,  $Exp(\beta) = 1.700$ ,  $p < 0.01$ ), 56% to increase the energy efficiency (i.e.,  $Exp(\beta) = 1.562$ ,  $p < 0.01$ ), but showed less propensity to pursue more radical eco-innovations (i.e.,  $Exp(\beta) = 0.701$ ,  $p < 0.01$ ). We did not get any significant results for the firms in the agriculture and hospitality industries.

4.4. Robustness and sensitivity tests results

Moreover, we performed robustness and sensitivity tests (see Table 4) to evaluate the structural validity of our main models. The models for component addition and eco-effectiveness proved to be robust and not sensitive to the exclusion of control variables (in concordance with the pseudo-R2 results). However, the models related to eco-efficiency (both materials and energy) demonstrated some degree of variation. We excluded the variables that did not show any significant results, were not robust, and were sensitive to control variables for further analysis.

4.5. The Summary of Results

The summary of our results is presented in Table 5. It includes the results of the main models, adjusted by the results of the robustness and sensitivity tests. The checkmark (X) means that cooperation or a particular external source of knowledge showed significant robust results. The double checkmark (XX) communicates the highest importance of explanatory variables for particular eco-innovation levels of radicalness. The squares in grey report the results that were not significant in the main models or were not robust.

We partially confirm our H1 and state that cooperation is positively associated with all levels of EI radicalness (excluding material

efficiency). Our results also fully confirm H2 and show that cooperation is particularly important when firms pursue radical EI (i.e., eco-effectiveness level). Regarding the external sources of knowledge, our empirical tests did not provide any significant and robust results for public clients, competitors, consultants, and universities. Although in some cases, the relationships between a particular knowledge source and different eco-innovation levels are significant in the main models, they are not in the robustness test models; therefore, such relationships are not robust, and thus we discarded them. However, the use of knowledge from suppliers, private clients, and public and private research centers showed a significant and robust positive relationship with various levels of EI radicalness. Finally, the use of knowledge from professional associations showed a significant and robust positive association with almost all the levels of EI radicalness. In the particular case of component addition level, we have to be cautious since the last variable appeared only in the 2016 addition of PITEC, and it was not possible to test the robustness. To sum up, we partially confirm H3 and state that external sources of knowledge are positively related to the different levels of EI radicalness. We also fully confirm H4 since we observed that the importance of external knowledge sources varies according to the levels of EI radicalness.

## 5. Discussion

This study intended to investigate how certain forms of open innovation approach, such as cooperation and the choice of external knowledge sources, affect various levels of EI radicalness based on the eco-innovation novelty and impact. We discuss the findings in the following section.

**First**, while the innovation and sustainability literature traditionally distinguish between incremental and radical types of EI (Arekrans et al., 2022; Chadha, 2011; Lin, 2016), our results show that radicalness is not a dichotomous characteristic and should be considered a spectrum (Aragón-Correa, 1998; Hart, 1995). In this study, we adopted a three-level framework of eco-innovation radicalness proposed by Carrillo-Hermosilla et al. (2010) and distinguished between the levels of component addition, eco-efficiency, and eco-effectiveness based on the eco-innovation novelty and impact. Each of the levels showed a unique relationship pattern with cooperation and sourcing external knowledge. Moreover, at the level of eco-efficiency, where organizations seek to increase their environmental performance through more efficient use of resources, there were some minor (but still) differences between material efficiency and energy efficiency. Our results support previous studies that related the radicalness of EI to the various types of environmental strategies (Klewitz and Hansen, 2014). For instance, Aragón-Correa et al. (2008) distinguished between reactive, proactive, and environmental leadership strategies. Noci and Verganti (1999) also offered three-level typology, including reactive, anticipatory, and innovation-based types of environmental strategies. Therefore, we conclude that the binary perspective might be limited to investigate the radicalness of EI, and future research should incorporate more levels for the proper analysis.

**Second**, our initial literature review revealed an important gap in the literature on OEI in understanding how various forms and modes of OI affect EI in general and the radicalness of EI in particular. For instance, Leitão et al. (2020) tried to compare the relationship between inbound OEI and outbound OEI and concluded that both modes have a positive impact on firms' environmental performance. There is also some evidence of successful crowdsourcing challenges that helped organizations to solve environmental issues (Bogers et al., 2020; Chesbrough, 2012). However, most of the studies use the term OEI as a homogeneous concept and as an umbrella term to refer to cooperation and the flow of knowledge and resources across the boundaries of organizations to develop EIs (Bigliardi and Filippelli, 2022; Chistov et al., 2021; Sanni and Verdolini, 2022). Our results reveal the differences between active cooperation with external organizations from just

sourcing external knowledge. Therefore, we conclude that each form and representation of OEI has its own unique characteristics that have to be considered and that may lead to differences in the relationships with various types of EI (i.e., based on the radicalness of EI).

**Third**, our study expands on the existing literature by providing a more comprehensive analysis of the role of cooperation in driving various levels of eco-innovation (EI) radicalness. While multiple previous studies (De Marchi, 2012; Mazzanti and Zoboli, 2009; Rennings and Rammer, 2011) have established the importance of cooperation in introducing EIs, our investigation offers a more nuanced understanding of its impact across different degrees of radicalness. We found that cooperation was positively associated with nearly all EI levels of radicalness except material efficiency. This result supports previous findings that cooperation is crucial for introducing incremental solutions to comply with basic environmental laws and regulations (i.e., end-of-pipe solutions) (Camisón, 2010; H. Lin, 2016) and for increasing eco-efficiency through reduced energy consumption (Vaiyavuth, 2012). Moreover, we add to the findings of Inigo et al. (2020) and Mothe and Nguyen-Thi (2016) by reinforcing that cooperation is particularly vital when firms aim to introduce more radical solutions to address complex environmental issues (i.e., eco-effectiveness). This distinct insight underscores the essential role of cooperation as a key element of the OEI strategy, not only for developing EI (European Commission, 2013) but also for tackling pressing environmental challenges (Bogers et al., 2020) and effecting systemic changes in the current industrial, economic, and political systems (Curley and Salmelin, 2018; McGahan et al., 2021).

**Fourth**, while overall, external sources of knowledge were positively associated with all levels of EI radicalness, we found major distinctions regarding the importance of each one when we disaggregated them into individual sources. In spite of the major attention to the role of suppliers in EI and some evidence that supplier integration is positively linked with radical EI (Zhang et al., 2020), our results show that knowledge from suppliers is mostly associated with the end-of-pipe and eco-efficiency solutions, particularly with energy efficiency. This coincides with previous research showing that knowledge sourcing and partnership with suppliers are positively associated with incremental EI but not necessarily with radical EI (Zhang et al., 2020; Zhao et al., 2020). The knowledge from private clients was positively associated with all the levels of EI radicalness, particularly with eco-effectiveness. These results support the seminal studies from the innovation literature that suggest that organizations that have a strong market orientation and that involve their end users and customers in the innovation process are more prompt to develop radical solutions (Narver and Slater, 1990; von Hippel, 2005). Sourcing the knowledge from research institutions was also deemed to be particularly important for more radical EIs. This dynamic can probably be explained by the differences in the type of knowledge that organizations receive from the knowledge partners. As we have already discussed, radical EIs on many levels are more complex than other types of innovations, therefore, they might require very specialized technical knowledge that may be developed exclusively with the experience and infrastructure of research institutions (Belin et al., 2011).

**Finally**, we also observe the general lack of active cooperation among the firms during the innovation process (only 52.1%) and much less whenever the firm pursues eco-innovation objectives (around 23%). The lack of cooperation has been shown to be one of the major barriers to EI (Polzin et al., 2016). Our results reveal a paradox where cooperation is needed to achieve environmental goals (particularly radical ones), but there is still a big percentage of organizations that do not reach out for knowledge and resources outside their organizational boundaries. This coincides with previous studies that also showed the general lack of collaboration during EI R&D (Chistov et al., 2021). In agreement with other authors, we suppose that while firms may understand the importance of cooperation and OEI in general, they may be hesitant to adopt it due to various internal constraints (the availability of resources, the lack of experience), as well as inherent

challenges of cooperation itself (i.e., conflicts of interests, mismatch of common objectives, communication issues, free-riding behavior of partners) (Hermann et al., 2016).

## 6. Conclusions, limitations, and directions for future research

The aim of this study was to contribute to the literature and overall understanding of OEI by analyzing the effect of an open innovation approach on EI and, in particular, how cooperation and access to external knowledge affect various degrees of EI radicalness based on eco-innovation novelty and impact.

This study has some limitations that might be addressed in future research. First, the context of our sample is limited to Spain. However, our methodology can be easily replicated for all the countries that adopted Community Innovation Survey (CIS). Similar data is available for European countries, India, South Korea, Chile, and Mexico. Also, the results of our study indicated that choosing the sample based on the industry, the size or age of the firm may also impact the relationship between open innovation and radicalness of eco-innovation. While our sample is equally representative of small, medium, and large businesses, most of them are mature firms with more than 40 years of existence. Future studies could use the same methodology to analyze firms in different stages of their development. Second, in our study, we faced limitations related to the choice of indicators to measure the radicalness of eco-innovation. Due to the unavailability of certain variables in the data, we had to rely on proxies as substitutes, which may not fully capture the essence of the original variables. This could potentially impact the accuracy and comprehensiveness of our findings, and further studies may wish to explore alternative indicators or data sources to better measure eco-innovation radicalness. Also, we treated cooperation as a monolithic concept and did not delve into its various characteristics, such as depth and breadth. Future research could explore the diverse aspects of cooperation, assessing how these characteristics may influence the relationship between open innovation strategy and eco-innovation radicalness. Third, while we employed logistic regression in our study, the PITEC database might also be appropriate to employ other statistician methods that offer additional insights. Finally, we base our explorations on the conceptual framework proposed by Carrillo-Hermosilla et al. (2010). While it provides a solid theoretical foundation for our research, it is important to note that multiple frameworks have been put forward in the last decade, each offering distinct perspectives and approaches to studying eco-innovation. As a result, future research may benefit from exploring alternative frameworks or even combining elements from different models to develop a more comprehensive understanding of eco-innovation radicalness and its relationship with open innovation.

This study was motivated by both academic and practical reasons. We hope that the theoretical implications of our research will bring further advancements in the understanding of the role of the open innovation approach in developing eco-innovations, as well as a closer and more detailed investigation of various characteristics, forms, and approaches to OEI. From the practitioners' perspective, we hope that our results provide a framework for organizations to choose the key external knowledge sources and partners based on their EI objectives and to decrease the risk of mismatch between them, thus taking advantage of the positive effects of OEI and avoiding the potential pitfalls. Finally, our results showed the crucial importance of both public and private research centers for more radical EI. Therefore, if policymakers would like to accelerate the transition of countries towards more sustainable modes of operation, they have to take a close look at how to support their research institutions and how to secure their flow of knowledge with the industry.

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## Declaration of Competing Interest

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

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## **7. DISCUSSION AND CONTRIBUTIONS**

Each study that forms a part of this work has a distinct focus. However, all together, they tell a story about the complex relationship between sustainability, innovation, and business performance. The dissertation starts by analyzing the decision of organizations to adopt sustainability objectives (i.e., sustainability orientation), including environmental or social, and their potential impact on business performance during various stages of the firm's life cycle. It also highlights the importance of reconciling sustainability and innovation and delves into eco-innovation. Then it gives an overview of the concept of Open Eco-innovation and the research that explores how organizations can overcome the barriers to eco-innovation by using open innovation strategies, thus bridging together the literature on eco-innovation and open innovation. Finally, the research investigates the crucial dependence of various types of eco-innovation on collaboration and active search for external knowledge, particularly when firms pursue more radical environmental solutions. In this chapter, we summarize the significant findings of this dissertation and discuss our contributions to sustainability, eco-innovation, and open eco-innovation literature.

### **7.1. Main Findings and Contribution to the Research Questions**

Our first and second research questions were an inquiry into the relationship between sustainability orientation (environmental and social orientation) and business performance. In Study 1, we examined the impact of sustainability orientation on the growth of small entrepreneurial firms at various stages of their development. Our findings suggest a positive and significant effect of sustainability orientation on firm growth in the mature stage (i.e., after 5 years of the firm paying salaries). This indicates that once firms establish themselves in the marketplace, they are better equipped to balance sustainability objectives with business growth. We also identified an important distinction between different types of sustainability goals. While pursuing environmental goals increased the likelihood of a firm's growth for mature-stage firms, pursuing social goals did not have a statistically significant effect. In conclusion, our study highlights the potential positive relationship between sustainability orientation, particularly environmental orientation, and long-term business performance.

Our third and fourth research questions focused on the relationship between sustainability orientation (both environmental and social), innovation, and business

performance. In line with previous research, our findings (Study 1) demonstrated that innovation positively and significantly impacts firms' business performance (i.e., growth), especially as they progress in their lifecycle. However, we did not observe a significant moderation effect of innovation in the relationship between sustainability orientation (both environmental and social) and business performance. This suggests that there may be challenges in the relationship between sustainability orientation and innovation. Despite the recognized complementarity and importance of innovation for sustainability, our results indicate that this relationship can be complex and may not always yield the expected positive outcomes, particularly for small entrepreneurial firms.

The fifth research question of this work focused on the concept of Open Eco-innovation and intended to understand the different approaches to the research into this concept. Our results (Study 2) show a significant growth in interest to open innovation strategies whenever organizations employ innovations to pursue environmental objectives. We also identified that the research into OEI evolves on three major levels of analysis. On a macro-level, researchers look into the potential benefits of OEI for industrial ecosystems (Pichlak & Szromek, 2022), the national and global economy, and the natural environment (Bigliardi & Filippelli, 2022; Garcia et al., 2019). On a meso-level, the focus is on the benefits of knowledge transfer and cooperation for the firm's environmental and economic performance (De Marchi, 2012). Here, the creation and capture of shared value among partners, optimal cooperation models, and the depth and breadth of these relationships are essential considerations (Chang et al., 2017; González-Moreno et al., 2019). At the micro-level, researchers examine individual attitudes of employees and management towards OEI implementation and investigate organizational factors that may influence its success. Such factors include firm size and age, turnover rate, and the proportion of research and development expenses (Avellaneda-Rivera et al., 2020; Hansen & Klewitz, 2012; Pichlak & Szromek, 2021).

Our sixth research question tried to understand the relationship between open innovation and eco-innovation and how one affects the other. Our findings indicate that firms engaging in cooperation with external partners during the innovation process were more likely to pursue various eco-innovation goals. Specifically, these firms were 31% more likely to focus on compliance with environmental regulations, 23% more likely to prioritize energy efficiency, and 80% more likely to pursue more radical eco-innovations. Furthermore, the importance of external sources of knowledge was also evident. Firms that considered knowledge from

suppliers important were 47% more likely to focus on compliance with environmental regulations, 66% more likely to prioritize material efficiency, and 79% more likely to emphasize energy efficiency. Knowledge from private clients also played a significant role, with companies placing high importance on this knowledge being more likely to focus on compliance with regulations, material efficiency, energy efficiency, and more radical eco-innovations. Both public and private research centers were found to be crucial for achieving the highest level of eco-innovation radicalness (i.e., eco-effectiveness), with private research centers also playing a role in lower levels of eco-innovation radicalness. Lastly, knowledge from professional associations was essential for all types of eco-innovations, particularly for environmental compliance, materials efficiency, and energy efficiency. These findings highlight the importance of collaboration and external knowledge exchange in fostering eco-innovation and achieving sustainability goals. Organizations can benefit from external partnerships and access to diverse sources of knowledge to drive innovation and decrease their environmental impact.

Lastly, our findings show that firms' adoption of sustainability orientation is still relatively low, with only one out of every ten organizations actively pursuing sustainability goals (Study 1). Furthermore, our research indicates that when engaging in eco-innovations, only around half of the organizations implement open eco-innovation (OEI) strategies (Study 3).

## **7.2 Theoretical Contributions**

### *7.2.1 Contributions to Sustainability Literature*

**First**, our research findings highlight the critical role of companies in driving the sustainability transition of our society. However, in concordance with previous studies (Pandey et al., 2019; Roxas & Chadee, 2012), in general, this number is still small (less than 45%) and drops significantly among entrepreneurial ventures (less than 10%) (del Río et al., 2015). Our research also brings additional empirical evidence to the existing notion that the majority of environmental sustainability efforts, particularly among small firms (Pichlak & Szromek, 2021), are incremental (Aldieri & Vinci, 2020) and centred around essential regulatory compliance and material and energy consumption efficiency. And that only a small proportion of organizations pursue more radical environmental objectives. As such, there is a significant

opportunity for companies to increase their environmental sustainability efforts and drive positive societal change.

**Second**, our study contributes to the existing literature on sustainability by presenting new empirical evidence that examines the relationship between sustainability orientation and business performance. Our results support the existing argument (i.e., by Margolis & Walsh, 2001) that it is challenging to test this relationship due to multiple contextual factors affecting it. We show that such factors as the stage in the entrepreneurial life cycle, the size of the firm, the sector, and the type of sustainability objectives (i.e., environmental or social) indeed affect this relationship. However, in general, we lean towards a more positive outlook presented in studies by Bodhanwala & Bodhanwala (2018), Gómez-Bezares et al. (2017), and Soto-Acosta et al. (2016), and demonstrate that while the short-term effects of introducing sustainability objectives may not yield immediate business results, over the long term, organizations experience positive impacts on growth and business performance in general. Importantly, our study breaks away from the conventional focus on large organizations (Castka et al., 2004; Leonidou et al., 2017) by investigating this relationship within the context of small firms and new business ventures. As a result, our findings further enrich the rapidly growing literature on sustainable entrepreneurship and show empirical evidence that small and new organizations can also be important agents of change in the sustainability transition of our society (Gianiodis et al., 2022; Halme & Korpela, 2014; Olteanu & Fichter, 2022; Schaltegger et al., 2018). And that they can also benefit from sustainability-oriented practices to drive positive outcomes across diverse organizational parameters, in particular profitability and growth.

**Third**, this study challenges the current dominating tendency to analyze environmental and social dimensions under the overarching term of sustainability (i.e., sustainable entrepreneurship (Criado-Gomis et al., 2018; Hörisch, 2015; Lüdeke-Freund, 2020) or sustainable innovation (Aagaard & Lindgren, 2015; Abbas et al., 2020; Boons et al., 2013)). Our findings indicate that these dimensions, while seemingly interconnected, are distinctly different concepts with unique characteristics. Thus, lumping them together under the term "sustainability" may result in empirical inaccuracies and gaps in our understanding of the dynamics between these concepts. Interestingly, our research shows that firms adopting environmental objectives tend to exhibit greater growth than traditional firms not adopting them. In contrast, having a social orientation, although not significantly, was found to correlate negatively with a firm's business performance (i.e., growth). We agree with multiple previous

studies that this discrepancy could be due to the fact that environmental goals align better with business objectives, often resulting in immediate returns through reduced material and energy costs and the avoidance of governmental penalties (Carrillo-Hermosilla et al., 2009; Jové-Llopis & Segarra-Blasco, 2018; Nguyen et al., 2020). Socially-oriented organizations, on the other hand, are primarily rooted in the non-profit sector and prioritize social benefits over traditional business indicators such as profit and growth (Hoogendoorn et al., 2019). Moreover, the context-specific nature of social issues makes it challenging to transfer solutions across countries or social groups, hindering the scalability of social innovations – a critical aspect of attracting investments (Costanzo et al., 2014; Praszkiec & Nowak, 2011). Furthermore, there are situations where environmental objectives may conflict with social ones. For instance, the ongoing transition to renewable energy, while environmentally beneficial, has resulted in increased living costs for many people worldwide. Given these distinct characteristics and potential conflicts, we strongly recommend that environmental and social objectives be examined independently, as it was historically done in the academic literature (Thananusak, 2019), rather than collectively under the term "sustainability".

*Fourth*, we diverge from the traditional sustainability literature that characterizes sustainable innovation (i.e., eco-innovation) as either incremental or radical (Arekrans et al., 2022; Chadha, 2011; Lin, 2016). Our findings suggest that the concept of radicalness is not dichotomous but rather exists along a spectrum (Aragón-Correa, 1998; Hart, 1995). Thus, we adopted a nuanced three-tiered framework of eco-innovation radicalness from Carrillo-Hermosilla et al. (2010). This model differentiates between component addition, eco-efficiency, and eco-effectiveness, based on the novelty and impact of the eco-innovation. We observed distinct patterns of cooperation and external knowledge sourcing across these levels. Particularly in the eco-efficiency level, where organizations strive for enhanced environmental performance through resource consumption efficiency, we found subtle but notable variations between material and energy consumption efficiency. Thus, this study underscores the importance of considering the gradations of eco-innovation radicalness in further research and practice.

### 7.2.2 Contributions to Open Eco-Innovation Literature

**First**, a thorough review of the existing literature reveals that the majority of challenges associated with eco-innovation could be overcome if organizations effectively supplement their internal R&D processes with external resources, knowledge, and expertise (Kobarg et al., 2020; Murillo-Luna & Hernández-Trasobares, 2023; Rauter et al., 2017; Thomas et al., 2022). That can be done in various ways, i.e., forging formal partnerships for collaboration and knowledge exchange (Alos-Simo et al., 2023; Camarinha-Matos et al., 2022; Mishra et al., 2021), participating in industry networks (Breuer & Lüdeke-Freund, 2017; Conway & Steward, 1998), organizing challenges (Bogers et al., 2020; Chesbrough, 2012), leveraging crowdsourcing platforms to harness the ingenuity of a large number of individuals and other organizations (Hörisch, 2018; Tenner, 2021), and engaging with government initiatives and programs (Bongaerts & Heinrichs, 1987; Demirel & Kesidou, 2011; Van Luin & Van Starckenburg, 1988). These strategies, while being separately examined in sustainability and innovation literature, all fall under the umbrella term of Open Innovation (Chesbrough, 2003; Chesbrough & Bogers, 2014). In our research, we adopt the term “Open Eco-Innovation” (OEI) as a consolidating way to address all activities that facilitate the inflow of external resources and knowledge to complement internal eco-innovation development, as well as those that aid organizations in the commercialization of their in-house knowledge on eco-innovation solutions (Civelek et al., 2020; Ghisetti et al., 2015; Leitão et al., 2020). We show a significant and consistent surge in research on this subject since 2010, and the term 'OEI' is increasingly gaining recognition and acceptance in academia and industry (Bigliardi & Filippelli, 2022; Cano & Londoño-Pineda, 2020; Chistov et al., 2021; Sanni & Verdolini, 2022).

**Second**, our study adds to the existing body of knowledge by providing an in-depth examination of the function of cooperation in fostering various levels of eco-innovation (EI) radicalness. Although earlier research has highlighted the importance of cooperation in adopting EIs (De Marchi, 2012; Mazzanti & Zoboli, 2009; Rennings & Rammer, 2011), our work gives a more nuanced view of its impact over a spectrum of radicalness. Except for material efficiency, we discovered that cooperation had a positive link with practically all EI radicalness levels. This finding is consistent with previous research demonstrating the importance of collaboration in implementing incremental eco-innovation solutions that comply with basic environmental laws and regulations (i.e., end-of-pipe solutions) (Camisón, 2010; Lin, 2016), as well as in improving eco-efficiency through lower energy consumption

(Vaiyavuth, 2012). Furthermore, our findings support those of Inigo et al. (2020) and Mothe & Nguyen-Thi (2016), emphasizing the necessity of collaboration when enterprises want to introduce more radical solutions to difficult environmental concerns (i.e., eco-effectiveness). This unique insight highlights the critical role of collaboration within an Open Eco-innovation (OEI) strategy, which is important not only for the evolution of EI (European Commission, 2013) but also for addressing urgent environmental concerns (Bogers et al., 2020) and initiating systemic transformations in our existing industrial, economic, and political frameworks (Curley & Salmelin, 2018; McGahan et al., 2021).

**Third**, our initial review of the literature revealed a significant gap in open eco-innovation (OEI) research, primarily concerning the influence of various open innovation (OI) modalities on eco-innovation (EI) and its degree of radicalism. While Leito et al. (2020) attempted to compare the effects of inbound and outbound OEI on the environmental performance of firms, they concluded that both modalities have a positive impact on environmental outcomes. In addition, successful crowdsourcing challenges have assisted organizations in addressing environmental concerns (Bogers et al., 2020; Chesbrough, 2012). Despite these efforts, the majority of studies use the term OEI, which encompasses a variety of cooperative efforts and cross-organizational knowledge and resource transfers aimed at EI development (Bigliardi & Filippelli, 2022; Chistov et al., 2021; Sanni & Verdolini, 2022). Our research findings, however, highlight the distinction between active collaboration with external entities and mere knowledge acquisition from external sources. Consequently, we infer that each OEI form possesses distinctive characteristics that merit consideration. These distinctive characteristics may influence associations with various EI categories, particularly when radicalness in EI is considered.

**The fourth** essential contribution of our study to OEI literature is the varied impact of diverse external sources of knowledge on levels of eco-innovation (EI) radicalness. Although external information was positively associated with all levels of EI radicalness overall, significant differences occurred when we examined each source separately. Despite significant attention to the role of suppliers in EI and evidence of a positive relationship between supplier integration and radical EI (Zhang et al., 2020), our research shows that supplier knowledge is primarily associated with incremental end-of-pipe and eco-efficiency solutions, particularly energy efficiency. This is consistent with previous research indicating that while supplier knowledge sourcing and partnerships are associated with incremental EI, they do not always

produce radical EI (Zhang et al., 2020; Zhao et al., 2020). Knowledge from private clients had a positive impact on all levels of EI radicalness, particularly eco-effectiveness, corroborating pioneering studies from the innovation field that assert that market-oriented organizations that involve end users and customers in the innovation process are more likely to develop radical solutions (Narver & Slater, 1990; von Hippel, 2005). Furthermore, we discovered that obtaining knowledge from research institutes is critical for radical EIs. This pattern is most likely explained by the nature of knowledge gained by organizations from these partners. As previously noted, radical EIs are frequently more difficult than other types of innovation and may necessitate specialized technical knowledge that is typically obtained inside the experiential framework and architecture of research institutions (Belin et al., 2011).

*Finally*, we see a general lack of active cooperation across firms during the innovation process (only 52.1%), and much less when the firm pursues eco-innovation goals (about 23%). One of the biggest barriers to EI has been identified as a lack of cooperation (Polzin et al., 2016). Our findings highlight a mismatch in which cooperation is required to attain environmental goals (especially radical ones), but a significant proportion of organizations do not reach out for expertise and resources outside their organizational bounds. This is consistent with prior research that found a widespread lack of teamwork throughout EI R&D (Chistov et al., 2021). We believe that while firms recognize the value of cooperation and OEI in general, they may be hesitant to implement it due to various internal constraints (availability of resources, lack of experience), as well as inherent challenges of cooperation itself (i.e., conflicts of interests, misalignment of common objectives, communication issues, free-riding behavior of partners) (Amin Zineldin, 1998; Collins & Gerlach, 2019; Hermann et al., 2015).

### **7.3 Practical Implications for Organizations and Policymakers**

This section aims to move from empirical results and theoretical conclusions to practical implications for organizations and recommendations for policymakers and provide concrete, actionable insights that organizations can implement to pursue sustainability.

### 7.3.1 Practical Implications for Organizations

*First*, while we acknowledge the possible problems of generalization of our results since our study focused exclusively on firms within the Spanish context, our findings reveal a clear trend indicating that a strong emphasis on sustainability, particularly in terms of environmental orientation, can not only coexist with but also enhance growth, and overall business performance. However, it is worth noting that this positive relationship may take time to manifest and may be more evident among well-established firms in the long run. Therefore, we encourage organizations not to be discouraged by any initial lack of immediate positive results when adopting a sustainability orientation. Instead, they must recognize that the desired outcomes will gradually emerge as they develop the necessary capabilities to reconcile environmental and business objectives effectively. With time and the cultivation of these capabilities, organizations can expect to witness the positive impacts of their sustainability initiatives on their overall performance.

*Second*, the first study of this dissertation underscored the crucial contribution of entrepreneurs and small businesses, highlighting their potential as catalysts for sustainable practices. It is important to acknowledge that small businesses may encounter unique challenges in navigating the complexities of sustainability. Nonetheless, we remain optimistic that our findings will serve as a source of encouragement for small firms to embrace sustainability, as the potential long-term benefits are worth the initial efforts and obstacles they may face. By adopting sustainable practices, small businesses can position themselves for success and contribute to the broader sustainability objectives, fostering a positive impact on both their own operations and the wider community.

*Third*, our findings demonstrate that innovation, particularly in organizations focused on sustainability, does not always produce the expected results right once, and the process might be complicated. Companies should be prepared to tackle these issues, which could include increased expenses, the need for technical skills, or even stakeholder resistance to change. Companies should foresee these challenges and establish strategic measures to overcome them. This could entail providing money for R&D or cultivating a corporate culture that emphasizes adaptation and resilience.

*Fourth*, given the challenges associated with implementing eco-innovation, it's clear that it's not something organizations can do alone. They should aim to build and maintain strong networks with external stakeholders, including other companies, non-profits, research institutions, or government agencies. These collaborations can provide invaluable resources, knowledge, and support, enabling firms to leverage shared expertise and navigate the complexities of sustainability together. The need for such extensive cooperation only increases when organizations aim to pursue more radical eco-innovation goals.

*Fifth*, sustainability is not a one-size-fits-all concept. Each company operates in a unique context, influenced by industry norms, regulatory frameworks, and stakeholder expectations. As such, companies should focus on customizing their sustainability practices to suit their specific situation. This might involve different approaches to stakeholder engagement, different emphasis on various sustainability issues, or distinct strategies for achieving sustainability goals. Our findings suggest that different eco-innovation goals may require different sources of knowledge. This means that firms should align their open innovation strategies with their strategic sustainability objectives and their unique context. This could involve actively seeking partnerships with specific entities that align with their sustainability goals and choosing the appropriate degree of breadth and depth of open innovation strategies. This alignment could ensure a more coherent and integrated approach to achieving both sustainability and business objectives.

*Finally*, it is critical for organizations to recognize that social objectives and environmental objectives are not one and the same. Each may require different approaches, resources, and stakeholder involvement. Companies need to make a conscious effort to distinguish between the two, setting distinct goals and developing tailored strategies to achieve them. Therefore, it may be necessary for the broader business and academic communities to rethink the definition of sustainability. A more nuanced understanding of sustainability that separates social and environmental objectives could lead to clearer strategies and more effective action, benefiting companies, society, and the environment.

### 7.3.2 Recommendations for Policymakers

*First*, considering the difficulty and challenges associated with sustainable innovation, policymakers should adopt regulations that encourage and support projects of this kind. This

could involve providing funds for research and development in sustainable technologies or offering tax incentives to companies that put an emphasis on eco-innovation.

*Second*, policymakers could establish platforms (both digital and offline) for collaboration among businesses, academic institutions, non-profits, and government agencies. These platforms can foster shared learning and knowledge exchange, helping businesses navigate the complexities of eco-innovation. They should also develop policies that incentivize businesses to adopt open innovation strategies. These policies could include tax breaks for companies that share intellectual property related to sustainability or grants for projects that involve multiple external collaborators.

*Third*, policymakers should facilitate businesses to access existing knowledge on sustainable technologies and approaches by providing access to specially curated databases of research findings, best practices, and benchmarks.

*Fourth*, policymakers should consider the unique contexts and challenges that different industries face when designing sustainability policies. Customized, sector-specific policies may be more effective in promoting sustainable practices.

*Fifth*, policymakers should promote and support sustainability education and training in the business sector. This could involve funding training programs or policies that require companies to provide sustainability training to their employees. This would ensure that companies have the knowledge and skills necessary to implement sustainable practices effectively.

## **8. CONCLUSIONS, LIMITATIONS, AND FUTURE RESEARCH**

### **8.1 Concluding Remarks**

This research aims to explore the complex relationship between sustainability orientation, innovation, and business performance. While previous studies have emphasized the challenges of integrating sustainability objectives into business operations (Gupta et al., 2013; Stevens et al., 2015), our findings provide evidence that, in the long run, companies that prioritize sustainability are more likely to achieve growth and profitability. These results support the notion that pursuing sustainability objectives can generate societal value alongside the market value derived from innovative products or services. This combined value can help overcome the costs and difficulties inherent in the development and implementation of sustainable practices. This work adds empirical evidence to the “revisionist” literature that sees sustainability orientation as a source of sustainable competitive advantage rather than a weakness and negative disruption of business activities. It is also a testament to evolving nature of our society towards a shift towards a new market paradigm, where sustainability goes hand in hand with economic prosperity and growth (Ndubisi & Nair, 2009; Shepherd & Patzelt, 2011).

Our study also reveals that both sustainability orientation and innovation individually contribute to the growth of a firm. However, when examining the relationship between sustainability and growth, we find that innovation does not act as a moderating factor in our sample. It is important to note that our analysis focuses on general innovation rather than eco-innovation specifically and includes product and service innovations that are not explicitly designed for sustainability purposes. Based on these findings, we interpret that merely being innovative may not be enough for a firm with a sustainability orientation. Instead, the firm's innovation efforts must also align with sustainability goals, particularly those related to the environment. Therefore, it is the combination of sustainability orientation and sustainability-oriented innovation (i.e., eco-innovation) that is more likely to drive business performance and facilitate growth

In addition to our findings on the relationship between sustainability orientation, innovation, and business performance, our study also sheds light on a new stream of research into the concept of Open Eco-innovation. This emerging field explores the use of open innovation strategies to foster the development and implementation of novel environmental

solutions, contributing to the broader sustainability transition. We demonstrate an increasing interest in leveraging open innovation approaches to drive positive environmental change and promote the adoption of more sustainable practices within organizations. Our research highlights the significance of Open Eco-innovation, particularly when organizations aspire to make substantial and transformative changes in their production and delivery methods, aiming for a more radical shift toward sustainability.

## 8.2 Limitations and Future Research

This work has several limitations that can be addressed in future studies.

*First*, our research is cross-sectional, considering only data from one year: 2019 in study 1 and 2016 in study 3. The classic management literature (Rogers, 2010), as well as the conclusions from our Study 1, suggest that the benefits of implementing new practices within an organization may not be immediately apparent and that there may exist a time gap between the adoption of innovative strategies and the consequent observable results. As a result, while our findings are useful in understanding the fundamental relationship between sustainability orientation, business performance, and innovation activities, we believe that it is also important to examine it in dynamic mode and consider the potential lag effect between implementation and results. Consequently, future longitudinal research endeavors can be considered using the data from the Panel Study of Entrepreneurial Dynamics project and exploring various time spans within the PITEC database. This could lead to a more nuanced understanding of the interplay between sustainability, innovation, and business performance.

*Second*, according to institutional theory, the functioning and decision-making processes of organizations are significantly influenced by an array of external factors. These organizations encounter numerous challenges that can be administrative, financial, cultural, or informational in nature (Amoros & Stenholm, 2014; M. Zhao et al., 2021). Our study is situated within the particular context of Spain, a member of the European Union, which entails adherence to a common set of laws, regulations, and financial systems. Despite these shared attributes, which enable Spain to act as a representative of developed nations, we anticipate the existence of distinct local characteristics that might influence our study's findings. Consequently, if our methodology were to be replicated in different contexts, there might be certain differences in the outcomes. This disparity could be especially noticeable when

comparing developed and developing countries. The Global Entrepreneurship Monitor (GEM) and Community Innovation Survey (CIS) databases provide comprehensive datasets that allow the application of our methodology across a range of countries globally. Therefore, future studies could examine the interaction between sustainability, innovation, and business performance in various nations. Such comparisons would offer deeper insights into the unique institutional factors and barriers that could influence these interrelationships.

*Third*, traditionally, the academic focus on sustainability has been centered in the context of large companies. However, in recent years, there has been an upsurge in academic literature, with a greater emphasis on Small and Medium-sized Enterprises (SMEs). This shift stems from an implicit understanding that small and large firms bear fundamental differences in their structures and functions. Future research might consider small, medium, and large organizations, thereby facilitating empirical comparisons among these diverse organizational types. Furthermore, research into sustainability orientation and eco-innovation span a wide range of industries. Therefore, future studies across various industries would allow to compare the interplay between sustainability, innovation, and business performance within and between diverse sectors. This comparative analysis could improve our understanding of sector-specific influences on sustainability orientation, business performance, and innovation.

*The fourth* limitation of our study is related to our approach to measuring variables. For instance, we adopted a simplified method to assess a firm's sustainability orientation (Calic & Mosakowski, 2016; Testa et al., 2020). This method determines whether a firm seeks environmental or social objectives in addition to purely economic ones. However, there are more sophisticated tools available to evaluate this concept through multiple variables (Hörisch, 2018). Moreover, we examined the business performance of the firm through the lens of the firm's growth in terms of turnover and employment, though we acknowledge that business performance can be measured in many other ways. Therefore, we propose that future research delve deeper into this subject and explore alternative ways of measuring sustainability orientation and its intensity, whether weak or strong (Santos et al., 2013). Similarly, future studies should consider different types of innovation, such as product, process, or business model innovations, and varying intensities and scopes of cooperation (De Marchi, 2012; Ghisetti et al., 2015), which would contribute to a more nuanced understanding of these factors and their impacts.

*Fifth*, in our first study, we examine the broad concept of sustainability orientations, delving into the distinctions between environmental and social orientations. Our conclusions indicate that social orientation has no positive relationship with firms' growth. Furthermore, we argue that it may be misguided to group environmental and social issues under a single umbrella of sustainability, considering their distinct foundations and potential conflicts between them. Thus, in the following studies (2 and 3), we decided to focus solely on environmental objectives and Open Eco-Innovation (OEI). However, it's crucial to clarify that these findings should not deter further exploration into social entrepreneurship and innovation. We recognize that social challenges constitute the grand issues of our society, and ultimately, they also impact environmental issues. Moving forward, we suggest that future research consider studying the “sister” concepts of OEI, such as "open social innovation" and "open sustainable innovation." We believe that a thorough examination of these concepts could reveal the full potential of the Open Innovation (OI) approach in supporting the sustainability transition in our society.

*Lastly*, our bibliometric study (study 2) maps out the significant aspects of Open Eco-Innovation's (OEI) development in academic literature over the past three decades. However, we acknowledge that the recognition of collaboration as a vital tool for tackling major sustainability challenges predates this period and finds its roots in classic economic literature. Consequently, we propose that future research should delve deeper into this pertinent literature, offering a more thorough exploration of the evolution of economic thought on the subject of OEI. Moreover, we assert that it would be beneficial to analyze the concept of OEI in conjunction with and in relation to the dominant management theories in the current academic business literature in order to understand the impact of OEI within the broader context of business and management studies.

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