Received: 20 September 2022 | Revised: 21 February 2023 | Accepted: 2 March 2023

DOI: 10.1002/sd.2541

RESEARCH ARTICLE

Sustainable Development WILEY

Factors driving national eco-innovation: New routes to sustainable development

Nuria Chaparro-Banegas[1] | Alicia Mas-Tur[2] | Han Woo Park[3] | Norat Roig-Tierno[1]

[1]Universitat Politècnica de València, València, Spain

[2]Universitat de València, València, Spain

[3]YeungNam University, Gyeongsan, South Korea

Correspondence
Nuria Chaparro-Banegas, Universitat Politècnica de València, Camí de Vera, s/n, 46022 València, Spain.
Email: nchaban@upv.es

Funding information
Generalitat Valenciana, Grant/Award Number: GV/2021/121; Ministerio de Ciencia e Innovacion, Grant/Award Number: FPU20/06043

Abstract

Each country has its own set of unique elements and institutions to foster innovation within its boundaries. This combination of elements and institutions is known as an innovation system. Innovation has been used to boost countries' growth and competitiveness for decades. However, it is a much questioned strategy because it may compromise the opportunities of future generations and thus sustainable development. Hence, academics and policymakers are now turning to eco-innovation to create sustainability-based innovation systems that improve not only a country's economic efficiency but also people's well-being and quality of life. However, the uncertainty and complexity around eco-innovation hinder the creation and implementation of eco-innovation policies because of a failure to identify its drivers. The aim of this paper is to detect the national-level factors that are necessary or sufficient for eco-innovation in European countries. Fuzzy-set qualitative comparative analysis (fsQCA) is used for this purpose. The conditions in this analysis are governance, human capital capacity, research institutions, and public and private research and development (R&D) investment. The use of fsQCA to study eco-innovation systems is methodologically unique. The findings suggest that research institutions, human capital capacity, and public R&D investment are valuable for eco-innovation. Therefore, the findings of this study have implications for the design of policies aimed at creating businesses, enriching society, and boosting sustainable development through eco-innovation. Such policies should focus on education, social awareness, stakeholder engagement, support from research institutions, and public R&D investment.

KEYWORDS

eco-innovation, human capital, national innovation systems, R&D investment, research institutions, sustainable development

1 | INTRODUCTION

In recent decades, sustainable development has increasingly attracted the interest of society by placing eco-innovation in the spotlight (Hojnik & Ruzzier, 2016). Certain economic activities negatively affect the environment, but this type of innovation can reduce their environmental impact (Horbach, 2016; Koseoglu et al., 2022) while improving people's wellbeing and countries' economic competitiveness (Păcesilă & Ciocoiu, 2017; Porter & van der Linde, 1995). Therefore, eco-innovation has a twofold impact by reinforcing both sustainability

This is an open access article under the terms of the Creative Commons Attribution-NonCommercial-NoDerivs License, which permits use and distribution in any medium, provided the original work is properly cited, the use is non-commercial and no modifications or adaptations are made.
© 2023 The Authors. *Sustainable Development* published by ERP Environment and John Wiley & Sons Ltd.

10991719, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1002/sd.2541 by University Di Roma La Sapienza, Wiley Online Library on [14/03/2023]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

and competitiveness. Accordingly, it has an ability to exert beneficial effects on both these areas simultaneously. This ability resolves the trade-off between either promoting environmental issues or boosting competitiveness that has troubled some authors (e.g., Andersen, 2004) in relation to aligning environmental policies with innovation to create sustainable economic value. For example, Bossle et al. (2016) argued that sustainability and economic competitiveness can be promoted through an eco-innovation-based approach. Companies can achieve competitive advantages due to their improved reputation and image from adopting new green processes and products (Chen et al., 2017).

Several authors have argued that factors other than innovation and eco-innovation stimulate competitiveness (e.g., Aiginger & Firgo, 2017; Sánchez de la Vega et al., 2019). Research by Mas-Verdu et al. (2020) has shown that, for a region to be competitive, high public and private R&D spending is necessary, as is having national-level universities ranked among the top 300 in the world. Similarly, the combination of collaboration between companies, high levels of human capital, and private R&D investment can help create competitive regions (Garcia-Alvarez-Coque, Mas-Verdú, & Roig-Tierno, 2021). These factors are also related to eco-innovation. Hence, fostering these elements could have a double impact on competitiveness by (i) exerting a direct effect and (ii) creating an indirect effect driven by eco-innovation.

Eco-innovation is characterized by a systemic and dynamic process of relationships between different factors and agents (Pacheco et al., 2018). Eco-innovation occurs within the borders of a region with national and regional innovation systems. These innovation systems encompass a set of characteristics based on culture, history, policies, and other aspects (Cooke et al., 1997). Tödtling and Trippl (2005) highlighted the importance of having an in-depth knowledge of the characteristics of the national innovation system because countries may have diverse innovation contexts.

The myriad of factors that affect eco-innovation complicates the adoption of policies that effectively promote eco-innovation (del Río et al., 2010; Díaz-García et al., 2015). This paper shows which national characteristics are necessary or sufficient to stimulate eco-innovation performance in European countries. Fuzzy-set qualitative comparative analysis (fsQCA) was used to do so. Five conditions were included in the research model. To the best of the authors' knowledge, no fsQCA studies have examined innovation systems and sustainability together, making this research unique.

The five conditions included in this study are governance, human capital capacity, research institutions, public R&D investment, and private R&D investment. These five factors are fundamental because economic agents such as governments, firms, employees, students, universities, and research institutions can influence the adoption of sustainable actions by companies and society (Horbach, 2016; Orlando et al., 2020; Păcesilă & Ciocoiu, 2017; Rosca et al., 2018). International sustainability strategies call these agents to action by participating in innovation and knowledge processes. The strongest social, human, academic, scientific, and business capital can thus join forces (Reverte, 2022). The results suggest that, despite the absence of necessary conditions, human capital capacity, research institutions, and public R&D investment play a crucial role in explaining eco-innovation. Moreover, the lack of human capital capacity and public and private R&D investment may lead to the failure of eco-innovation at the national level.

Section 2 of this paper contextualizes eco-innovation by describing its relationship with innovation systems, competitiveness, and the conditions included in the analysis. Section 3 introduces the fsQCA method and describes the data. The results are presented in Section 4. Section 5 discusses the results. Section 6 presents the conclusions of the study.

2 | THEORETICAL FRAMEWORK

The literature cites numerous elements that may influence eco-innovation. In particular, Díaz-García et al. (2015) identified a series of drivers of eco-innovation grouped into three levels: micro-, meso-, and macro-level drivers. These factors include personnel, networking, public and private financing, R&D cooperation, norms and regulation, and subsidies. This section establishes five propositions related to the factors included in the analysis, namely governance, human capital capacity, research institutions, public R&D investment, and private R&D investment.

2.1 | Innovation systems

Over the years, innovation has become an essential strategy for boosting economic development and competitiveness. In addition to supporting the development of innovation policies, regional innovation systems enable the identification, analysis, and understanding of the creation, development, and possible trends in regional innovation characteristics (Asheim & Isaksen, 2002; Cooke, 1998). National innovation systems, the national analog of regional innovation systems (Cooke et al., 1997), consist of a set of interconnected elements and institutions located within the borders of a nation (or region in the case of regional innovation systems), which contribute to the creation, dissemination, and use of new technologies and knowledge (Freeman, 1987; Lundvall, 2016; Mieg, 2012). Each geographical area has unique characteristics that justify the implementation of different national policies. There is no single national policy model that applies everywhere. Best practices depend on the spatial environment (Tödtling & Trippl, 2005) because socioeconomic factors shape the development of innovation differently in different contexts (Lu et al., 2020; Tabrizian, 2019). The fact that some countries succeed in innovation by applying specific measures and practices does not necessarily guarantee the success of another country with different characteristics. However, the strategies of another country could serve as a model or starting point to study the country's specific situation.

Numerous elements interact within an innovation system's frontier. The N-Helix models complement innovation system theory by considering the existence of N elements that interact within the borders of a nation or region. The latest N-Helix model is the Sextuple Helix (López-Rubio et al., 2021), based on the Triple Helix

10991719, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1002/sd.2541 by University Di Roma La Sapienza, Wiley Online Library on [14/03/2023]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

(Etzkowitz & Leydesdorff, 2000). These N-Helix models emerged to cover the limitations of the Triple Helix model because it is crucial to understand the social implications of socio-technical transitions (Park & Stek, 2022). These models integrate innovation and sustainability by aligning the goals of the private sector, government, and universities to provide transformative solutions to economic, social, and environmental challenges (Chindasombatcharoen et al., 2022; Etzkowitz & Zhou, 2006; Lew & Park, 2021).

2.2 | The role of governance

Over the past few decades, policymakers, academics, and other agents have focused on sustainable governance given society's desire for greater transparency and participation in public affairs (Chung & Park, 2018). Regional policy can encourage consumers and producers to ground their choices and actions in sustainability and the notion that the circular economy can have an essentially positive effect on the economy, society, and the environment (Smol et al., 2017). Given that innovation policy is not usually inclined toward sustainability (Reid & Miedzinski, 2008), the role of the government may be crucial.

Public institutions and agencies can formulate more sustainable policies that benefit the environment while contributing to economic and social development through, for example, effective innovation measures regarding pollution and resource conservation (Chen et al., 2017). For example, the European Commission has tried to increase awareness and commitment of the circular economy to encourage the sustainable behaviors of consumers and producers (Camilleri, 2020). According to Reverte (2022), public policies can drive sustainable development by improving economic freedom, governance systems, and institutional quality, while supporting the innovation and education ecosystems. Thus, policymakers should try to align environmental and innovation policy. Whereas the former internalizes the external costs arising from non-environmentally friendly but commercialized products and services, the latter seeks to reduce the cost of social, institutional, and technological innovation (Rennings, 2000). Such alignment can lead to synergies between the two policies. These synergies help integrate different aspects of sustainability in the economic process (Andersen, 2004). Various policy instruments have been introduced to encourage the adoption of eco-innovation. Examples include subsidies, funds, energy contracting, tax advantages, negotiated agreements, and other non-financial instruments (Panapanaan et al., 2014). Horbach et al. (2012) argued that government subsidies have a significant positive impact on environmental innovation because they reduce the cost of introducing eco-innovation (Tsai & Liao, 2017). Similarly, governments also play an important role in fostering innovation cooperation between different actors (Kwon, 2020), which facilitates the flow of information from knowledge generators such as universities and research centers to eco-innovation developers such as companies (del Río et al., 2015; Pereira et al., 2020). Nevertheless, the complementarities and conflicts between them have not been studied in detail (Díaz-García et al., 2015).

Proposition 1. *Governance leads to high eco-innovation at the country level.*

2.3 | Human capital capacity: Education, awareness, skills, and capabilities

Given the increasing social and government concern and awareness about sustainable development, firms have used their internal drivers to identify the need to introduce innovation strategies based on environmental sustainability (Liao et al., 2020). Such strategies allow them to react proactively to sustainability challenges (Bossle et al., 2016). Human capital can determine the creation of a country's technical capacity because (i) a country's innovations rely on the talent and skills of its residents and (ii) the level of human capital is a key factor in a country's technical absorptive capacity (Benhabib & Spiegel, 1994; Zhen, 2011). Moreover, eco-innovations require more knowledge and resources than other innovations (Ukko et al., 2019). Hence, business actions related to training, dissemination, and information can stimulate eco-innovation by enhancing the absorptive capacity of human resources (Díaz-García et al., 2015). Choi et al. (2021) found that firms with links to educational institutions introduce CSR values associated with the academic sector. Hence, relationships between the private and educational sectors may have a spillover effect on society through the acceptance of sustainable innovation principles that influence human capital, namely students and employees.

The development of human capital increases environmental awareness, leading to the adoption of more efficient technologies and renewable energies (Broadstock et al., 2016; Li et al., 2020) and the reduction of environmental degradation (Khan, 2020). Hence, a country's technological and ecological capabilities could be enhanced through training and information strategies in eco-innovation at all levels of education, from undergraduate to master's or PhD levels (Chen et al., 2017). If so, education could become a pivotal way of encouraging eco-innovation. Orlando et al. (2020) reported a positive relationship between eco-innovation and the management of human capital, as well as its skills and capabilities. Therefore, adequate human capital management, through actions to raise awareness of sustainability, can increase the involvement of employees and even society in general, with people becoming more willing to engage in eco-innovation. Shou et al. (2019) argued that social and environmental principles become part of a firm's decision-making when it has a long-term internal commitment to sustainable development (Chindasombatcharoen et al., 2022).

Proposition 2. *A strong human capital capacity leads to high levels of national eco-innovation.*

2.4 | Universities and research institutions

Sustainable development challenges urgently require innovation collaboration among different agents (Milana & Ulrich, 2022). Collaboration in innovation in general and specifically in eco-innovation can be

10991719, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1002/sd.2541 by University Di Roma La Sapienza, Wiley Online Library on [14/03/2023]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

fostered through universities and research institutions (Miozzo et al., 2016). These organizations possess professional expertise and knowledge through which they provide a wide range of complex and specialized services (Lessard, 2014; Szutowski, 2021). The activities they perform are primarily associated with product innovation, requiring technical expertise in consulting, engineering R&D, and software and hardware, among other areas (Cainelli et al., 2020). Firms, especially small and medium-sized enterprises (SMEs), need to collaborate with external partners to create value and develop solutions that address sustainability challenges (Ukko et al., 2019).

Sáez-Martínez et al. (2016) showed a negative relationship between research institutions and eco-innovation by analyzing the technological behavior of 212 SMEs. However, they concluded that more in-depth analysis would be needed to confirm this conclusion. Many researchers have argued that this relationship between eco-innovation and research centers or universities is positive (e.g., Cainelli et al., 2012; del Río et al., 2017). For instance, Petruzzelli et al. (2011) suggested that companies with external and internal networks tend to perform eco-innovation. Therefore, creating and employing external networks, including relationships with universities, could offer possibilities and opportunities by enhancing eco-innovation capacity (Horbach, 2016). Similarly, del Río et al. (2016) claimed that cooperation between multiple agents such as universities, competitors, governments, and other firms is necessary for eco-innovation.

Proposition 3. *The contribution of research institutions is essential to stimulate a country's eco-innovation.*

2.5 | Public and private R&D investment

Countries may differ in their eco-innovation performance and activity because of differences in factors such as their level of R&D (Ghisetti et al., 2015). For example, within the European Union, Eastern European countries, except Hungary, have lower eco-innovation performance because of their lower R&D expenditure than Western European countries (Horbach, 2016). According to Cheng and Shiu (2012), the probability of success in environmental innovation increases in firms with higher R&D investment (Mercado-Caruso et al., 2020) because firms improve and update their technological capabilities based on environmental principles (Horbach, 2008). Therefore, countries or companies that allocate more resources to R&D may be more willing to introduce eco-innovation and eco-innovation strategies because of less uncertainty around eco-innovation and a lower probability of failure.

However, authors do not agree about the relationship between eco-innovation and R&D investment. Whereas some researchers have reported that R&D has a neutral effect on eco-innovation (O'Brien & Torugsa, 2011), others deny the existence of a positive relationship and argue that further research is needed to confirm the role of R&D in eco-innovation (del Río et al., 2017; Horbach et al., 2013). Some scholars (e.g., Díaz-García et al., 2015) have claimed that technological capabilities such as R&D positively affect innovation, but not green innovation. Several authors (e.g., David et al., 2000; Long & Liao, 2021; Orlando et al., 2020) have shown that, although investment in R&D has a positive impact on eco-innovation, this type of innovation is still mainly driven by the public sector, with minimal investment by companies. The reason for this finding, among other aspects, is that the public sector tends to be more long-term oriented and less risk-averse than the business sector.

In contrast, other studies have shown that the private sector is the main developer and investor in eco-innovation (Jiménez-Parra et al., 2018; OECD, 2010). Private R&D investment can also reduce firms' environmental impact without negatively affecting its economic performance (Hojnik et al., 2022). For instance, Jové-Llopis and Segarra-Blasco (2018) showed that the internal R&D spending of eco-innovation-oriented firms is higher than that of non-eco-innovation-oriented firms. This finding suggests that the R&D requirements of eco-innovation are greater and, therefore, that the development of eco-innovation may be more limited when the necessary financial resources to ensure its success are not available. Scarpellini (2022) argued that private investment is one of the main drivers of the circular economy, also contributing through the increase in eco-innovation activities (Scarpellini et al., 2020).

Proposition 4. *The presence of high levels of public R&D investment contributes to eco-innovation.*

Proposition 5. *The presence of high levels of private R&D investment contributes to eco-innovation.*

3 | METHOD AND DATA

Charles Ragin developed qualitative comparative analysis (QCA) in 1987 as a methodology for quantitative data, qualitative data, or a combination of both (Ragin, 1987). Although QCA was initially designed for use with small data sets, it is also suitable for use with larger samples (Fiss, 2011; Garcia-Alvarez-Coque, Roig-Tierno, et al., 2021; Vis, 2012). This technique uses Boolean algebra to obtain combinations of conditions, represented by simplified expressions, that lead to an outcome of interest (Fiss, 2007). QCA is directly related to the concept of equifinality, which reflects the idea that diverse and mutually non-exclusive pathways lead to the occurrence of the same phenomenon (Legewie, 2013; Schneider & Wagemann, 2012; Wagemann & Schneider, 2010). Therefore, equifinality allows for the identification of different combinations of explanatory factors, known as conditions, that lead to the same outcome. This property helps provide an understanding of the necessary conditions that explain why an outcome is present or absent (Roig-Tierno et al., 2017).

QCA cannot automatically explain the non-occurrence of an outcome purely based on the explanation of the occurrence of the outcome. A condition, or configuration of multiple conditions, indicates only one of the two qualitative states of the outcome: presence

10991719, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1002/sd.2541 by University Di Roma La Sapienza, Wiley Online Library on [14/03/2023]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

or absence (Schneider & Wagemann, 2012). These conditions are necessary or sufficient causes to explain the occurrence or non-occurrence of an outcome. A condition is necessary when it is present in all the configurations that lead to the outcome. In contrast, a condition is sufficient when it always leads to the outcome (Lucas & Szatrowski, 2014). Nevertheless, other sufficient conditions may also cause the outcome (Ragin, 2008; Roig-Tierno et al., 2017). Moreover, the outcome can also occur when this condition is absent.

The two specific methods in QCA are crisp-set qualitative comparative analysis (csQCA) and fuzzy-set qualitative comparative analysis (fsQCA). CsQCA defines the outcome and conditions as binary structures (Wagemann & Schneider, 2010). The binary code used with each explanatory condition is 0 when the condition is absent, meaning that the condition is "fully outside" the set, and 1 when the condition is present, meaning that the condition is "fully inside" the set (Marx et al., 2013). In contrast, fsQCA cases are classified as continuous. They are assigned a value between 0 and 1, where the value represents the degree of membership in the set (Tur-Porcar et al., 2017). A condition can be fully outside the set, corresponding to a membership score of 0, fully inside the set, corresponding to a membership score of 1, or neither inside nor outside the set (point of maximum ambiguity), corresponding to a membership score of 0.5 (García-Álvarez-Coque et al., 2017; Ragin, 2000).

Using these membership scores, fsQCA can identify the necessary and sufficient conditions that explain the presence and absence of eco-innovation. Authors have cited different factors as determinants of innovation (e.g., Bossle et al., 2016; López-Rubio et al., 2021). It is reasonable to assume that eco-innovation is also influenced by many of these factors because it encompasses the uncertainty and complexity of not only innovation but also sustainability. The analysis of eco-innovation systems through fsQCA makes this research methodologically unique.

Data were collected for European countries for the year 2021 from several data sources. The data on national eco-innovation were obtained from the Eco-Innovation Index (European Commission, 2022a). The data on governance were collected from the Governance Performance Index. This index is a sub-index of the Global Sustainable Competitiveness Index (SolAbility, 2022). It is based on quantitative indicators provided by UN agencies, the World Bank, and the International Monetary Fund. The data on human capital capacity and public and private R&D investment were gathered from the European Innovation Scoreboard (European Commission, 2022b), which offers data on the innovation performance of European countries.

Data on research institutions were gathered from the Scimago Institutions Rankings (SCImago, 2022). Some transformations were applied to these data. The institutions in this ranking were classified into four quartiles. These quartiles were assigned the following scores: 100 points for Q1, 75 points for Q2, 50 points for Q3, and 25 points for Q4. The calculation of the score per quartile for each country involved taking the number of institutions of each country in a given quartile and multiplying it by the corresponding score assigned to the quartile. This process was repeated for each quartile. The sum of the quartile scores gave the country's total score in the Scimago IR. Finally, the value of the research institutions condition for each country was calculated by dividing the total score by the total population multiplied by 1000 inhabitants. Calculations were performed for European countries only. The variables integrated within the framework of national and regional innovation systems are shown in Figure 1. The aim was to determine the national conditions that lead to high eco-innovation performance.

The raw data were calibrated using the direct method (Ragin, 2008). This method establishes three qualitative thresholds or anchors: full membership (1), full non-membership (0), and the crossover point (0.5). The crossover point represents the point of maximum ambiguity, where it is not possible to determine whether a case is more "inside" or "outside" a set (Ragin, 2009). Calibration is the process of assigning set membership scores to cases (Schneider & Wagemann, 2012). Typically, the anchors should be determined with theoretical and substantive knowledge (Ragin, 2000). However, in cases where researchers do not possess sufficient knowledge, they

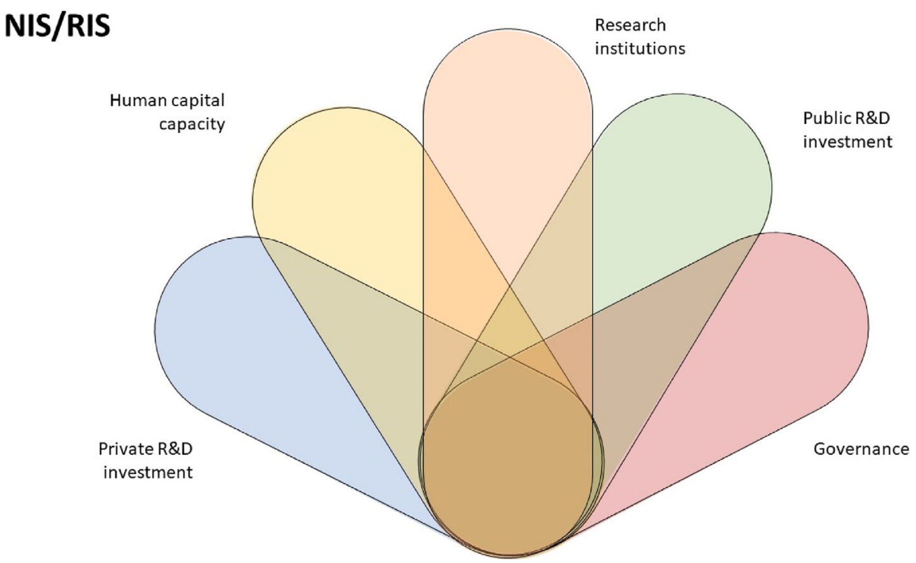

FIGURE 1 Eco-innovation conditions. *Source*: Authors based on Horbach (2016), Păcesilă and Ciocoiu (2017), Rosca et al. (2018), and Orlando et al. (2020). [Colour figure can be viewed at wileyonlinelibrary.com]

10991719, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1002/sd.2541 by University Di Roma La Sapienza, Wiley Online Library on [14/03/2023]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

TABLE 1 Calibration and descriptive statistics of the outcome and conditions.

Condition/concept	Full membership	Crossover point	Full non-membership	Max	Min	Mean (SD)
Eco-innovation	128.98	107.48	85.99	171	50	107.48 (31.48)
Public R&D investment	0.57	0.47	0.38	1	0.02	0.47 (0.28)
Private R&D investment	0.50	0.41	0.33	1	0.05	0.41 (0.29)
Human capital capacity	0.55	0.46	0.36	0.81	0.06	0.46 (0.20)
Governance	70.08	62.50	57.77	73.17	57.56	62.50 (4.07)
Research institutions	0.33	0.28	0.22	0.52	0.09	0.28 (0.12)

Note: Full membership: 20% above the EU average; Crossover point: average of the sample; Full non-membership: 20% below the EU average.

TABLE 2 Analysis of necessary conditions for eco-innovation.

Conditions tested	Consistency	Coverage
Presence of		
Public R&D investment	0.733	0.774
Private R&D investment	0.653	0.807
Human capital capacity	0.762	0.779
Governance	0.559	0.600
Research institutions	0.802	0.788
Public or private R&D investment	0.786	0.726
Absence of		
Public R&D investment	0.312	0.295
Private R&D investment	0.366	0.307
Human capital capacity	0.299	0.291
Governance	0.560	0.522
Research institutions	0.262	0.266

TABLE 3 Recipes for eco-innovation.

	Models			
Conditions	1	2	3	4
Public R&D investment	•	•	•	○
Private R&D investment		•	•	
Human capital capacity		•		•
Governance	○			•
Research institutions	•		•	•
Raw coverage	0.380	0.500	0.517	0.195
Unique coverage	0.044	0.072	0.087	0.133
Consistency	1	0.932	0.963	0.871
Solution coverage: 0.818				
Solution consistency: 0.909				

Note: Following the notation of Fiss (2011), "•" indicates the presence of a condition, whereas "○" indicates its absence. Large and small circles represent core and peripheral conditions, respectively. However, in this case, all conditions are core conditions represented by large circles.

can identify the anchors using the properties of the study's sample (Greckhamer et al., 2018). In this case, all the conditions and the outcome were calibrated according to the criteria of the Regional Innovation Scoreboard (European Commission, 2021) and the study of Garcia-Alvarez-Coque, Mas-Verdú, and Roig-Tierno (2021). Table 1 presents the calibration thresholds and descriptive statistics of the outcome and conditions.

4 | RESULTS OF fsQCA ANALYSIS OF ECO-INNOVATION

4.1 | Necessary and sufficient conditions for eco-innovation

For the necessity analysis, shown in Table 2, both the presence and absence of the conditions were considered. These conditions were the elements that drive a country's eco-innovation. The analysis reveals no necessary condition for national eco-innovation because the consistency threshold of 0.9 was not exceeded by any condition (Ragin, 2008; Schneider & Wagemann, 2012). Hence, governance, human capital capacity, research institutions, private investment in R&D, and public investment in R&D by themselves are not necessary for eco-innovation to occur.

The implication of the results of the necessity analysis is that eco-innovation requires a combination of conditions. The conditions research institutions, human capital capacity, and public investment in R&D have consistency scores of 0.802, 0.762, and 0.733, respectively. Moreover, they cover 78.8%, 77.9%, and 77.4% of cases, respectively. Hence, although they are not necessary conditions, they appear to be relevant in explaining the presence of eco-innovation. At the national level, no specific type of R&D investment (public or private) increases eco-innovation performance. Nevertheless, the presence of at least one type of R&D investment is important in explaining national eco-innovation because it has a consistency score close to 0.8, accompanied by a case coverage of 72.6%.

Based on the sufficiency analysis shown in Table 3, the research model is acceptable because it has a consistency score exceeding the limit of 0.75 (Ragin, 2008). The model has a consistency score of 0.9, accompanied by a high case coverage (81%). Table 3 reveals that all combinations of conditions have a consistency score of more than 0.85. Models 1, 2, 3, and 4 have a consistency score of 1, 0.93, 0.96, and 0.87, respectively. The models refer to the different pathways

10991719, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1002/sd.2541 by University Di Roma La Sapienza, Wiley Online Library on [14/03/2023]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

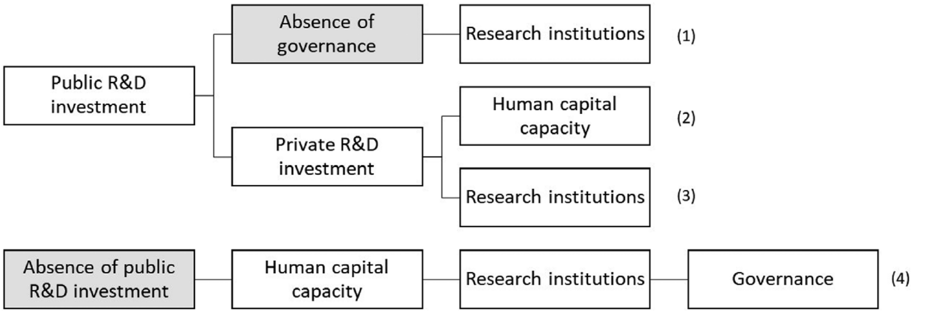

FIGURE 2 Graphical representation of the pathways that lead to eco-innovation.

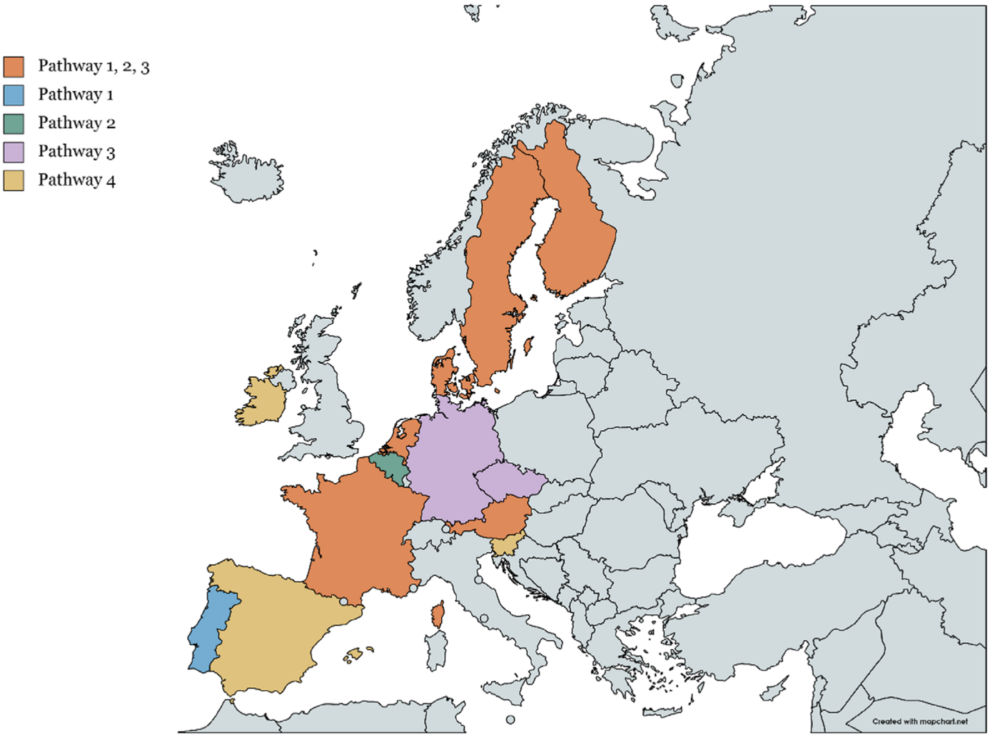

FIGURE 3 Country recipes leading to eco-innovation performance. [Colour figure can be viewed at wileyonlinelibrary.com]

that explain high levels of eco-innovation in a country. The black circles ("•") represent the presence of the condition in the pathway and the white circles ("○") represent its absence (Fiss, 2011). Research institutions and public R&D investment are crucial for promoting a country's eco-innovation because both conditions appear in three of the four recipes that lead to the outcome. This result exemplifies the equifinality that characterizes the QCA methodology because four different recipes lead to national eco-innovation. Both findings are also shown in Figure 2, which graphically represents the four pathways that explain eco-innovation.

Considering the intermediate and parsimonious solutions, the core and peripheral conditions were identified. The intermediate solution shows the causal conditions with a robust causal relationships with the outcome. The parsimonious solution indicates a weaker causal relationship (Fiss, 2011). In this case, public investment in R&D, private R&D investment, governance, human capital capacity, and research institutions are considered core conditions. In addition, the absence of public investment in R&D and the absence of governance are also core conditions.

The first pathway suggests that a country that allocates public financial resources to R&D, has advanced research institutions, and has a low level of governance can succeed in implementing eco-innovation. Countries with high eco-innovation performance with this combination of conditions include Sweden, France, the Netherlands, and Portugal. The second configuration consists of public and private investment together with human capital capacity. The countries with eco-innovation under this combination of conditions include Denmark, Finland, Sweden, France, the Netherlands, Austria, and Belgium. The third combination is similar to the previous one, except with research institutions replacing human capital capacity. The countries that follow this pattern are Finland, France, Sweden, Austria, Germany, Czechia, the Netherlands, and Denmark. A final question is whether it is possible to achieve high levels of eco-innovation without public investment in R&D. Although public investment in R&D is also a key element, as mentioned above, it is not essential because it could be replaced by a high level of governance, human capital capacity, and research institutions. These conditions constitute Pathway 4. Fewer countries follow this pathway, namely Ireland, Spain, and Slovenia.

10991719, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1002/sd.2541 by University Di Roma La Sapienza, Wiley Online Library on [14/03/2023]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

The country composition of each pathway is illustrated in Figure 3. The countries that achieve high levels of eco-innovation through more than one pathway are also represented in Figure 3. For Sweden, France, and the Netherlands, high levels of eco-innovation are explained through pathways 1, 2, and 3. These pathways highlight the role of public R&D investment, which suggests that their contribution through R&D investment is crucial to ensure eco-innovation activities among the different agents of the innovation system. In contrast, the high eco-innovation levels of Denmark, Finland, and Austria are explained through pathways 2 and 3. These two pathways illustrate the need for R&D investment collaboration between the public and private sectors. They indicate that a common commitment to sustainable development would boost R&D in technologies and innovations that positively influence the national economy, society, and environment. Therefore, these common characteristics that advanced economies require to achieve high levels of eco-innovation place the focus on different agents: (i) the public sector and institutions and (ii) the collaboration and joint involvement of the private and public sectors, which requires networks between different agents of the eco-innovation system.

A notable case is that of Portugal, which follows pathway 1, unlike Spain, Slovenia, and Ireland, which follow pathway 4. Pathway 4 stresses the relevance of human capital and research institutions. Spain, Portugal, and Ireland generally have similar socioeconomic attributes. Czechia offers another interesting case, following pathway 3 along with the economies of Western and Central Europe.

4.2 | Necessary and sufficient conditions for the absence of eco-innovation

In addition to helping identify the conditions that lead to eco-innovation, fsQCA also identifies the conditions leading to the non-occurrence of the outcome. The necessity analysis shows that the conditions are not necessary to explain the absence of eco-innovation because the consistency is less than 0.9 (see Table 4). However, high values are observed when private R&D investment is not present (consistency of 0.844). Hence, despite not being a necessary condition, the absence of private R&D investment plays an important role. The former statement could also be extended to the absence of public investment in R&D, human capital capacity, and research institutions, which have a consistency score of 0.78.

In this case, the absence of public or private R&D investment impedes eco-innovation (consistency of 0.927). Hence, if a country's companies or public bodies fail to allocate financial resources to R&D, the level of eco-innovation will be low or practically zero. Notably, having either type of investment is not a necessary condition for the presence of a country's eco-innovation. However, the absence of public or private R&D investment is a necessary configuration to explain the absence of eco-innovation.

In the sufficiency analysis, the solution consistency (0.896) exceeds the limit established by Ragin (2008). Table 5 shows the pathways or recipes that explain the absence or low levels of eco-innovation in a country. All pathways are described by the absence of conditions from the research model (white circles, "○"). Large and small circles indicate core and peripheral conditions, respectively (Fiss, 2011). Table 5 shows that the absence of research institutions, governance, public R&D investment, and private R&D investment leads to the absence of eco-innovation because they appear in three of the four pathways. Nevertheless, the absence of human capital capacity plays a key role because it appears in all sufficient combinations in the model.

Comparing the intermediate and parsimonious solutions, three of the five conditions are revealed as core conditions. The conditions that have a strong causal relationship with the absence of national eco-innovation are the absence of human capital capacity, research institutions, and public R&D investment. The peripheral conditions (i.e., those that only appear in the intermediate solution) are the

TABLE 4 Necessary conditions leading to the absence of eco-innovation.

Conditions tested	Consistency	Coverage
Presence of		
Public R&D investment	0.257	0.273
Private R&D investment	0.175	0.217
Human capital capacity	0.276	0.284
Governance	0.490	0.528
Research institutions	0.279	0.275
Absence of		
Public R&D investment	0.787	0.747
Private R&D investment	0.844	0.710
Human capital capacity	0.785	0.768
Governance	0.629	0.589
Research institutions	0.785	0.800
Public or private R&D investment	0.927	0.700

TABLE 5 Recipes explaining the absence of eco-innovation.

	Models			
Conditions	1	2	3	4
Public R&D investment		○	○	○
Private R&D investment	○		○	○
Human capital capacity	○	○	○	○
Governance	○	○		○
Research institutions	○	○	○	
Raw coverage	0.391	0.387	0.552	0.393
Unique coverage	0.048	0.043	0.209	0.050
Consistency	0.863	0.893	0.912	0.871
Solution coverage: 0.693				
Solution consistency: 0.896				

Note: Following the notation of Fiss (2011), "•" indicates the presence of a condition, whereas "○" indicates its absence. Large and small circles represent core and peripheral conditions, respectively.

10991719, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1002/sd.2541 by University Di Roma La Sapienza, Wiley Online Library on [14/03/2023]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

absence of governance and private R&D investment. These conditions have a weaker causal relationship with the outcome.

Pathway 1 indicates that the absence of eco-innovation in a country is explained by the absence of private R&D investment, human capital capacity, governance, and research institutions. The countries with this combination of conditions are Greece, Italy, Slovakia, Romania, Bulgaria, and Poland. Pathway 2 consists of the absence of public R&D investment, human capital capacity, governance, and research institutions. Hungary, Italy, Slovakia, Romania, Bulgaria, and Poland have this combination of conditions. Pathway 3 consists of the absence of public R&D investment, private R&D investment, human capital capacity, and research institutions. The countries with this configuration are Romania, Bulgaria, Latvia, Slovakia, Malta, Poland, Croatia, and Italy. Finally, the absence of national eco-innovation is explained by the absence of public R&D investment, private R&D investment, human capital capacity, and governance (pathway 4). In this case, Italy, Slovakia, Romania, Bulgaria, Cyprus, and Poland follow this configuration.

Figure 4 illustrates the countries with the configuration of conditions corresponding to each pathway. Five countries (Italy, Slovakia, Romania, Bulgaria, and Poland) have low or non-existent eco-innovation performance through the four pathways identified in the analysis. This finding suggests that their country scores for the factors included in the research model to explain eco-innovation are very low. The agents of these eco-innovation systems do not trust the existing structures to boost eco-innovation: research institutions are weak and do not establish networks with the business sector; the human capital does not possess the knowledge, experience, and know-how necessary to design and implement sustainable technologies; public and/or private R&D investment is low; and government and institutional entities do not create a reliable structure to foster this type of eco-innovation.

Italy, Slovakia, Romania, Bulgaria, and Poland meet all configurations with consistencies above 0.5. However, Italy has a coverage of 9.1% in all four pathways, which is a small value. Italy, Slovakia, Romania, Bulgaria, and Poland have Eco-Innovation Index values of 124, 82, 71, 50, and 63, respectively. With the exception of Italy, these countries have some of the lowest values in the whole sample. These results suggest that economies with low eco-innovation performance fail the most in introducing initiatives to promote eco-innovation. Thus, their characteristics are consistent with more configurations because they tend to have lower values in the conditions, leading to the absence of eco-innovation.

5 | DISCUSSION

The rapid industrialization of countries around the world has triggered not only economic growth but also environmental deterioration and degradation (Huang et al., 2021; Khan et al., 2020). Sustainable development and the circular economy have been championed by international organizations and individual countries to prevent the negative impact of human activities. Sustainable development, which is built on the three dimensions of sustainability (economic, social, and environmental), still has its limitations (Díaz-García et al., 2015). The limitations of sustainable development are linked to current technological and social systems, which are framed by the environmental resources and the biosphere's ability to absorb the impacts of human activities (Brundtland, 1987). Continued economic growth has generated enormous amounts of CO_2 emissions, with negative implications for

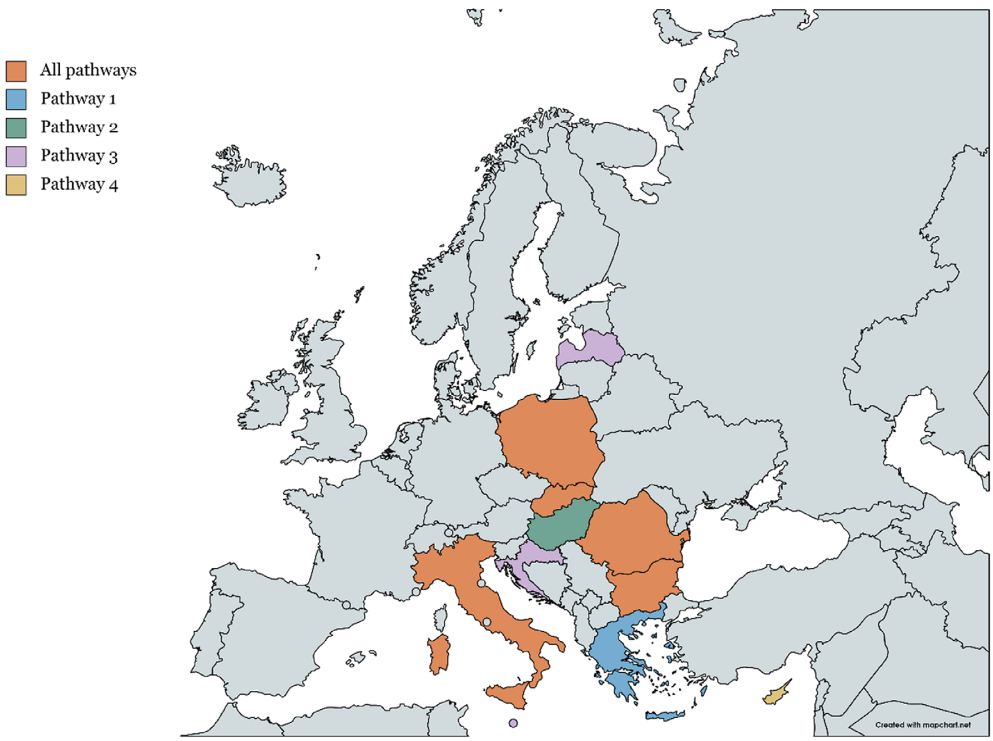

FIGURE 4 Countries with an absence of eco-innovation. [Colour figure can be viewed at wileyonlinelibrary.com]

10991719, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1002/sd.2541 by University Di Roma La Sapienza, Wiley Online Library on [14/03/2023]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

society and the environment (Li et al., 2020). Therefore, environmental responsibility has become a key issue worldwide (Fernández et al., 2021).

The transition toward sustainable development and the circular economy can be driven by eco-innovation (Scarpellini et al., 2020), which can support these two trends, despite the current economic, social, and environmental challenges (Milana & Ulrich, 2022). Eco-innovation can control pollution and mitigate its effects on the environment and society (Tao et al., 2021). This type of innovation supports not only goals addressed by traditional environmental actions and activities, such as the elimination of hazardous products, the reduction of pollution, the prevention of climate change, and the promotion of recycling, but also the creation of jobs, products, services, and competitive processes, and the raising of environmental awareness to bring about change in the behavior of individuals (Păcesilă & Ciocoiu, 2017). However, many factors influence eco-innovation. Therefore, finding a common method to improve overall eco-innovation performance is challenging (del Río et al., 2017). The literature classifies the drivers and barriers of eco-innovation using different criteria.

Díaz-García et al. (2015) showed the relevance of eco-innovation in academic research by reviewing the literature. According to their review, eco-innovation drivers can be grouped into three different levels. First, micro-level drivers are related to the value of entrepreneurs and the management, results, and performance of eco-innovation firms, as well as cost efficiency, reputation, and other such measures. Second, meso-level drivers relate to market dynamics such as market segments and new consumer needs. Finally, macro-level drivers are linked to specific policies and technological innovation systems. These micro-, meso-, and macro-level drivers correspond to drivers of eco-innovation at the national, regional, and sector/firm/individual levels, respectively (Zubeltzu-Jaka et al., 2018). Based on this classification, the drivers analyzed in this paper are macro-level drivers because the QCA was conducted at the country level to study national eco-innovation characteristics.

Other classifications separate drivers into internal and external factors that influence the decision to eco-innovate (del Río González, 2009). Internal factors (e.g., human resources, absorptive capacity, and internal financial resources) are firm characteristics or preconditions that encourage a predisposition toward or involvement in environmental technological change. External factors are stimuli or incentives that have the capacity to spark an entrepreneurial reaction. These factors include the interaction between different social, institutional, and market agents. Hojnik and Ruzzier (2016) distinguished between motivating factors, including regulatory pressure, customer demand, and expected profits of implementation, and enablers, such as technological capabilities and financial resources.

Zubeltzu-Jaka et al. (2018) grouped eco-innovation determinants into four clusters: market pull, technology push, regulatory push or pull, and firm-specific features. Market pull determinants relate to customer and supplier performance (including the demand for eco-products, customer benefits, and suppliers) and firm performance (including cost savings, economic performance, and sales forecasts). Technology push determinants involve R&D, collaboration among different economic agents, and environmental concern (e.g., organizational and resource commitment, training, and awareness). Regulatory factors cover command-and-control instruments (e.g., regulations and regulatory pressures) and economic incentives (e.g., subsidies, taxes, and public support for eco-innovation activities). Finally, firm-specific factors relate to firm size and age. This classification is similar to that of Fernández et al. (2021), who grouped the drivers of eco-innovation in developed and developing countries into market pull, regulatory push-pull, and technological push, which is in turn divided into firms' resources and capabilities (R&D related elements) and collaboration with partners, alliances, and networks.

Some of the barriers identified by scholars are high related costs, lack of funding sources, excessive perceived risks (Reid & Miedzinski, 2008), lack of environmental awareness or demand (EIO, 2011), lack of training opportunities, knowledge, and human capital (Cainelli et al., 2012), cooperation (Kiefer et al., 2019), and incentives and regulatory policies (Dias Angelo et al., 2012). These barriers are closely linked to the drivers of eco-innovation, suggesting that the presence or absence of these factors affects the development of eco-innovation activities within a country or region. Accordingly, QCA cannot automatically explain the non-occurrence of an outcome (in this case, eco-innovation) purely based on the explanation of the occurrence of the outcome. QCA results for an outcome are not symmetrical in terms of combinations of factors. A condition, or configuration of multiple conditions, indicates only one of two qualitative states of the outcome: presence or absence (Schneider & Wagemann, 2012). That is, the factors or conditions related to eco-innovation may be inversely related or unrelated to the same event (Douglas et al., 2020). Therefore, the barriers that explain the absence of national eco-innovation may not correspond to the absence of the drivers that explain the presence of eco-innovation.

When considering the configurational nature of phenomena, scholars can delve deeper and enrich their prior conclusions from regression methods (Ragin, 2006; Rihoux, 2006). Instead of detecting a single net effects model, which ignores the minority relationships between the outcome and conditions, QCA identifies and analyzes all types of relationships between independent (conditions) and dependent (outcome) variables (Douglas et al., 2020). QCA thus avoids the problems that arise when regression methods try to explain complex phenomena such as eco-innovation because such phenomena may be influenced differently depending on the case study and conditions considered in the analysis. QCA enables the analysis of asymmetric relationships between the outcome (eco-innovation) and conditions (drivers and barriers), without excluding interdependencies among them. The use of fsQCA to examine eco-innovation at the national level makes this research unique. To the best of the authors' knowledge, no fsQCA studies have explored sustainable development and innovation systems together. Methodologies employed to analyze eco-innovation at the firm, regional, or national level include bibliometric analyses, literature reviews, econometric techniques, and regression analyses.

10991719, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1002/sd.2541 by University Di Roma La Sapienza, Wiley Online Library on [14/03/2023]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

This paper complements the existing literature by providing a finer-grained understanding of eco-innovation complexity by recognizing the interdependence of conditions and adapting to data asymmetry. Building from the factors identified by literature reviews and empirical studies, this paper analyzes the eco-innovation systems of European countries to establish different pathways to national eco-innovation. The framework of eco-innovation systems represents commitment to and concern for the sustainable development of the private and public sectors, institutional and governance structures, R&D institutions, and society.

6 | CONCLUSIONS

In contrast to previous causally structured assertions, this research studies individual conditions that lead to a specific outcome. The analysis does not consider either independent or dependent variables. The paper's objective was to determine the necessary and sufficient conditions that result in high national eco-innovation performance. Given that eco-innovation simultaneously involves the complexity and uncertainty of innovation and sustainability, eco-innovation may be affected by many different factors, while having diverse relationships with them. In this case, public R&D investment, private R&D investment, governance, human capital capacity, and research institutions were studied as conditions that may lead to higher national eco-innovation performance.

Five main conclusions can be derived from this study. First, high levels of human capital capacity, research institutions, and public R&D investment seem to be crucial for boosting national eco-innovation. Hence, the introduction of measures that stimulate collaboration between different agents of the national and regional innovation systems could provide countries with a powerful business and social context to enhance the country's growth and competitiveness through strategies based on sustainability and eco-innovation. Prior studies, such as that of Mas Verdú (2021), suggest that intermediaries facilitate and expand firms' knowledge acquisition. However, companies cannot effectively achieve the knowledge acquisition process unless they complement their internal resources and capabilities with the external resources provided by intermediaries. This knowledge acquisition is essential for driving innovation (Miles et al., 2018).

Second, although the literature cites public and private R&D investment as relevant for innovation (García-Álvarez-Coque et al., 2017), in the case of eco-innovation, only the participation of governments and public administrations through investment in R&D is essential. Along these lines, Fabrizi et al. (2018) concluded that private actors' contribution to eco-innovation is lower than that of public actors. This finding may indicate that the involvement of non-business agents is crucial for high performance in eco-innovation because the challenges that arise when simultaneously dealing with innovation and sustainability are greater.

Third, human capital capacity is essential for eco-innovation. Hence, there is a need to promote human capital not only through education and training but also through new policies that encourage society to contribute to citizens' well-being and quality of life through sustainability and eco-innovation actions and initiatives. This finding is in line with those of Scarpellini et al. (2017), who argued that human capital involved with R&D and innovation activities drives the eco-innovation process. Moreover, the absence of this condition is one of the major barriers to eco-innovation, indicating that a society without the professional capabilities and skills necessary to drive eco-innovation leads to the absence of eco-innovation. Blättel-Mink (1998) contemplated the extent to which society recognizes sustainable development as a common global objective and is willing to embrace its three dimensions in its decision making and actions. Therefore, a lack of programs to raise awareness and train students, workers, and society could become one of the biggest threats to a region's eco-innovation.

Fourth, the absence of public or private R&D investment is necessary for the failure of national eco-innovation. This finding may imply that the level of eco-innovation in a region is low or practically nonexistent when firms or public institutions do not invest in R&D. The reason is that this investment is considered fundamental to the progress of eco-innovation practices (Scarpellini et al., 2017).

Finally, most developed countries in Europe (i.e., in Western and Central Europe) appear in more than one configuration for eco-innovation. This finding could explain their high scores in the Eco-Innovation Index because they possess high levels of many of the sufficient conditions behind eco-innovation (i.e., public investment in R&D, private investment in R&D, human capital capacity, and research institutions). These developed countries support high levels of eco-innovations through two major strategies: (i) public sector stimulation and encouragement of eco-innovation activities through R&D initiatives or (ii) the collaboration and joint participation of public and private sectors in R&D through networks of eco-innovation agents. In contrast, countries with low eco-innovation performance are found in Eastern and Southern Europe, implying that less developed economies (i.e., countries with a GDP per capita below the European average) are more likely to encounter barriers to eco-innovation.

This paper has some policy implications. Given the evidence that public R&D investment, human capital capacity, and research institutions are essential for national eco-innovation, policymakers should introduce measures and instruments that positively influence these elements. However, when designing and implementing these policies, policymakers should also consider the barriers that may hinder eco-innovation (i.e., public R&D, private R&D, and human capital capacity). Countries usually have limited resources, so they may be unable to address all aspects affecting this phenomenon. The creation of alliances based on transnational collaboration and cooperation could drive the success of eco-innovation and related initiatives because not every country has the same knowledge or experience to apply them effectively. When fostering international collaboration, studying the individual characteristics of countries may be important because the effectiveness of these policies may differ depending on the national context. Thus, eco-innovation and sustainability inequalities between countries can be reduced, allowing all economies to move together toward sustainable development.

10991719, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1002/sd.2541 by University Di Roma La Sapienza, Wiley Online Library on [14/03/2023]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Countries with low eco-innovation performance (i.e., Eastern and Southern European countries) or those trying to increase their eco-innovation performance should conduct in-depth analysis of their drivers and barriers. These countries could thus identify the factors that should be promoted to trigger high levels of eco-innovation. After having broad knowledge of the national characteristics of the eco-innovation system, less eco-innovative countries could seek countries with similar historical characteristics to find a reference to design and implement policies that promote eco-innovation. These policies could be based on (i) commitment from the public system to engage in eco-innovation activities by stimulating R&D or (ii) collaboration and networking among different agents within the country. This policy choice would depend on the influence and power of the public sector or the interrelationships and trust among different agents in the country.

This research is not without limitations. First, fsQCA reveals combinations of conditions related to an outcome. However, it does not explain why or how these conditions interact to lead to that outcome. Second, the set membership scores determined during the calibration process may depend on the assumptions of the research team. Hence, the research team's degrees of freedom may affect the findings of the analysis. This methodological problem of QCA is referred to as the "forking paths" problem (Gelman & Loken, 2014). Third, only five factors explaining eco-innovation were included in the analysis, despite the existence of other possible conditions. Finally, the study was static, and only countries in the European Union were examined. Consequently, future research opportunities include adding new eco-innovation determinants, as well as new cases from other non-European countries. Expanding research in this direction could help provide a broad, worldwide understanding of eco-innovation. Likewise, evolutionary analysis could identify changes in the importance of conditions or the continued presence of certain conditions over time.

ACKNOWLEDGMENTS

We acknowledge the support of the Spanish Ministry of Science and Innovation through the PhD Program FPU (ayudas para la Formación de Profesorado Universitario), granted to Nuria Chaparro-Banegas (FPU20/06043). Alicia Mas-Tur thanks the Generalitat Valenciana for funding under Project GV/2021/121 to support this research.

CONFLICT OF INTEREST STATEMENT

The authors report there are no conflicts of interest to declare.

ORCID

Nuria Chaparro-Banegas https://orcid.org/0000-0002-5907-5643
Han Woo Park https://orcid.org/0000-0002-1378-2473

REFERENCES

Aiginger, K., & Firgo, M. (2017). Regional competitiveness: Connecting an old concept with new goals. In R. Huggins & P. Thompson (Eds.), *Handbook of regions and competitiveness: Contemporary theories and perspectives on economic development* (pp. 155–191). Edward Elgar Publishing. https://doi.org/10.4337/9781783475018.00013

Andersen, M. M. (2004). An innovation system approach to eco-innovation-aligning policy rationales. In *The greening of policies-interlinkages and policy integration conference* (pp. 1–28).

Asheim, B. T., & Isaksen, A. (2002). Regional innovation systems: The integration of local 'sticky' and global 'ubiquitous' knowledge. *The Journal of Technology Transfer*, *27*(1), 77–86. https://doi.org/10.1023/A:1013100704794

Benhabib, J., & Spiegel, M. M. (1994). The role of human capital in economic development evidence from aggregate cross-country data. *Journal of Monetary Economics*, *34*(2), 143–173. https://doi.org/10.1016/0304-3932(94)90047-7

Blättel-Mink, B. (1998). Innovation towards sustainable economy – The integration of economy and ecology in companies. *Sustainable Development*, *6*(2), 49–58.

Bossle, M. B., Dutra De Barcellos, M., Vieira, L. M., & Sauvée, L. (2016). The drivers for adoption of eco-innovation. *Journal of Cleaner Production*, *113*, 861–872. https://doi.org/10.1016/J.JCLEPRO.2015.11.033

Broadstock, D. C., Li, J., & Zhang, D. (2016). Efficiency snakes and energy ladders: A (meta-)frontier demand analysis of electricity consumption efficiency in Chinese households. *Energy Policy*, *91*, 383–396. https://doi.org/10.1016/J.ENPOL.2016.01.009

Brundtland, G. H. (1987). *Report of the world commission on environment and development: Our common future*. World Commission on Environment and Development.

Cainelli, G., de Marchi, V., & Grandinetti, R. (2020). Do knowledge-intensive business services innovate differently? *Economics of Innovation and New Technology*, *29*(1), 48–65. https://doi.org/10.1080/10438599.2019.1585639/GEIN_A_1585639_MED0001.MP4

Cainelli, G., Mazzanti, M., & Montresor, S. (2012). Environmental innovations, local networks and internationalization. *Industry and Innovation*, *19*(8), 697–734. https://doi.org/10.1080/13662716.2012.739782

Camilleri, M. A. (2020). European environment policy for the circular economy: Implications for business and industry stakeholders. *Sustainable Development*, *28*(6), 1804–1812. https://doi.org/10.1002/SD.2113

Chen, J., Cheng, J., & Dai, S. (2017). Regional eco-innovation in China: An analysis of eco-innovation levels and influencing factors. *Journal of Cleaner Production*, *153*, 1–14. https://doi.org/10.1016/J.JCLEPRO.2017.03.141

Cheng, C. C., & Shiu, E. C. (2012). Validation of a proposed instrument for measuring eco-innovation: An implementation perspective. *Technovation*, *32*(6), 329–344. https://doi.org/10.1016/J.TECHNOVATION.2012.02.001

Chindasombatcharoen, P., Chatjuthamard, P., Jiraporn, P., & Treepongkaruna, S. (2022). Achieving sustainable development goals through board size and innovation. *Sustainable Development*, *30*(4), 664–677. https://doi.org/10.1002/SD.2264

Choi, J.-A., Park, S., Lim, Y. S., Nam, Y., Nam, I., & Park, H. W. (2021). Network arrangements underlying strategic corporate social responsibility: Findings from globalized cyberspace and lessons for Asian regions. *Journal of Contemporary Eastern Asia*, *20*(2), 19–34. https://doi.org/10.17477/JCEA.2021.20.2.019

Chung, C. J., & Park, H. W. (2018). Beyond data, innovation, social network, and convergence. *Quality & Quantity*, *52*(2), 515–518. https://doi.org/10.1007/S11135-017-0669-2

Cooke, P. (1998). *Introduction: Origins of the concept*. University of Illinois at Urbana-Champaign's Academy for Entrepreneurial Leadership Historical Research Reference in Entrepreneurship. https://papers.ssrn.com/abstract=1497770

Cooke, P., Uranga, M. G., & Etxebarria, G. (1997). Regional innovation systems: Institutional and organisational dimensions. *Research Policy*, *26*(4–5), 475–491. https://doi.org/10.1016/S0048-7333(97)00025-5

David, P. A., Hall, B. H., & Toole, A. A. (2000). Is public R&D a complement or substitute for private R&D? A review of the econometric evidence. *Research Policy*, *29*(4–5), 497–529. https://doi.org/10.1016/S0048-7333(99)00087-6

10991719, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1002/sd.2541 by University Di Roma La Sapienza, Wiley Online Library on [14/03/2023]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

del Río González, P. (2009). The empirical analysis of the determinants for environmental technological change: A research agenda. *Ecological Economics*, *68*(3), 861–878. https://doi.org/10.1016/J.ECOLECON.2008.07.004

del Río, P., Carrillo-Hermosilla, J., & Könnölä, T. (2010). Policy strategies to promote eco-innovation: An integrated framework. *Journal of Industrial Ecology*, *14*(4), 541–557. https://doi.org/10.1111/J.1530-9290.2010.00259.X

del Río, P., Carrillo-Hermosilla, J., Könnölä, T., & Bleda, M. (2016). Resources, capabilities and competences for eco-innovation. *Technological and Economic Development of Economy*, *22*(2), 274–292. https://doi.org/10.3846/20294913.2015.1070301

del Río, P., Peñasco, C., & Romero-Jordán, D. (2015). Distinctive features of environmental innovators: An econometric analysis. *Business Strategy and the Environment*, *24*(6), 361–385. https://doi.org/10.1002/BSE.1822

del Río, P., Romero-Jordán, D., & Peñasco, C. (2017). Analysing firm-specific and type-specific determinants of eco-innovation. *Technological and Economic Development of Economy*, *23*(2), 270–295. https://doi.org/10.3846/20294913.2015.1072749

Dias Angelo, F., Jose Chiappetta Jabbour, C., & Vasconcellos Galina, S. (2012). Environmental innovation: In search of a meaning. *World Journal of Entrepreneurship, Management and Sustainable Development*, *8*(2/3), 113–121. https://doi.org/10.1108/20425961211247734

Díaz-García, C., González-Moreno, Á., & Sáez-Martínez, F. J. (2015). Eco-innovation: Insights from a literature review. *Innovations*, *17*(1), 6–23. https://doi.org/10.1080/14479338.2015.1011060

Douglas, E. J., Shepherd, D. A., & Prentice, C. (2020). Using fuzzy-set qualitative comparative analysis for a finer-grained understanding of entrepreneurship. *Journal of Business Venturing*, *35*(1), 105970. https://doi.org/10.1016/J.JBUSVENT.2019.105970

EIO. (2011). *The eco-innovation challenge: Pathways to a resource-efficient Europe*. EIO.

Etzkowitz, H., & Leydesdorff, L. (2000). The dynamics of innovation: From National Systems and "Mode 2" to a Triple Helix of university–industry–government relations. *Research Policy*, *29*(2), 109–123. https://doi.org/10.1016/S0048-7333(99)00055-4

Etzkowitz, H., & Zhou, C. (2006). Triple helix twins: Innovation and sustainability. *Science and Public Policy*, *33*(1), 77–83. https://doi.org/10.3152/147154306781779154

European Commission. (2021). *Regional innovation scoreboard 2021*. Publications Office of the EU. https://op.europa.eu/en/publication-detail/-/publication/b76f4287-0b94-11ec-adb1-01aa75ed71a1/language-en

European Commission. (2022a). *El Plan de Acción sobre Ecoinnovación | Plan de Acción sobre Ecoinnovación*. European Commission. https://ec.europa.eu/environment/ecoap/about-action-plan/objectives-methodology_es

European Commission. (2022b). *European innovation scoreboard*. European Commission. https://research-and-innovation.ec.europa.eu/statistics/performance-indicators/european-innovation-scoreboard_en

Fabrizi, A., Guarini, G., & Meliciani, V. (2018). Green patents, regulatory policies and research network policies. *Research Policy*, *47*(6), 1018–1031. https://doi.org/10.1016/J.RESPOL.2018.03.005

Fernández, S., Torrecillas, C., & Labra, R. E. (2021). Drivers of eco-innovation in developing countries: The case of Chilean firms. *Technological Forecasting and Social Change*, *170*, 120902. https://doi.org/10.1016/J.TECHFORE.2021.120902

Fiss, P. C. (2007). A set-theoretic approach to organizational configurations. *The Academy of Management Review*, *32*(4), 1190–1198. https://doi.org/10.5465/AMR.2007.26586092

Fiss, P. C. (2011). Building better causal theories: A fuzzy set approach to typologies in organization research. *Academy of Management Journal*, *54*(2), 393–420. https://doi.org/10.5465/AMJ.2011.60263120

Freeman, C. (1987). *Technology policy and economic performance: Lessons from Japan*. Pinter Publishers.

García-Álvarez-Coque, J. M., Mas-Verdú, F., & Roig-Tierno, N. (2017). Technological innovation versus non-technological innovation: Different conditions in different regional contexts? *Quality and Quantity*, *51*(5), 1955–1967. https://doi.org/10.1007/S11135-016-0394-2/FIGURES/1

Garcia-Alvarez-Coque, J. M., Mas-Verdú, F., & Roig-Tierno, N. (2021). Life below excellence: Exploring the links between top-ranked universities and regional competitiveness. *Studies in Higher Education*, *46*(2), 369–384. https://doi.org/10.1080/03075079.2019.1637843

Garcia-Alvarez-Coque, J. M., Roig-Tierno, N., Sanchez-Garcia, M., & Mas-Verdu, F. (2021). Knowledge drivers, business collaboration and competitiveness in rural and urban regions. *Social Indicators Research*, *157*(1), 9–27. https://doi.org/10.1007/S11205-020-02478-6/FIGURES/3

Gelman, A., & Loken, E. (2014). The statistical crisis in science: Data-dependent analysis – A "garden of forking paths" – Explains why many statistically significant comparisons don't hold up. *American Scientist*, *102*(6), 460.

Ghisetti, C., Marzucchi, A., & Montresor, S. (2015). The open eco-innovation mode. An empirical investigation of eleven European countries. *Research Policy*, *44*(5), 1080–1093. https://doi.org/10.1016/J.RESPOL.2014.12.001

Greckhamer, T., Furnari, S., Fiss, P. C., & Aguilera, R. V. (2018). Studying configurations with QCA: Best practices in strategy and organization research. *Strategic Organization*, *16*(4), 482–495. https://doi.org/10.1177/1476127018786487

Hojnik, J., Prokop, V., & Stejskal, J. (2022). R&D as bridge to sustainable development? Case of Czech Republic and Slovenia. *Corporate Social Responsibility and Environmental Management*, *29*(1), 146–160. https://doi.org/10.1002/CSR.2190

Hojnik, J., & Ruzzier, M. (2016). What drives eco-innovation? A review of an emerging literature. *Environmental Innovation and Societal Transitions*, *19*, 31–41. https://doi.org/10.1016/J.EIST.2015.09.006

Horbach, J. (2008). Determinants of environmental innovation—New evidence from German panel data sources. *Research Policy*, *37*(1), 163–173. https://doi.org/10.1016/J.RESPOL.2007.08.006

Horbach, J. (2016). Empirical determinants of eco-innovation in European countries using the community innovation survey. *Environmental Innovation and Societal Transitions*, *19*, 1–14. https://doi.org/10.1016/J.EIST.2015.09.005

Horbach, J., Oltra, V., & Belin, J. (2013). Determinants and specificities of eco-innovations compared to other innovations—An econometric analysis for the French and German industry based on the community innovation survey. *Industry and Innovation*, *20*(6), 523–543. https://doi.org/10.1080/13662716.2013.833375

Horbach, J., Rammer, C., & Rennings, K. (2012). Determinants of eco-innovations by type of environmental impact – The role of regulatory push/pull, technology push and market pull. *Ecological Economics*, *78*, 112–122. https://doi.org/10.1016/J.ECOLECON.2012.04.005

Huang, Y., Xue, L., & Khan, Z. (2021). What abates carbon emissions in China: Examining the impact of renewable energy and green investment. *Sustainable Development*, *29*(5), 823–834. https://doi.org/10.1002/SD.2177

Jiménez-Parra, B., Alonso-Martínez, D., & Godos-Díez, J. L. (2018). The influence of corporate social responsibility on air pollution: Analysis of environmental regulation and eco-innovation effects. *Corporate Social Responsibility and Environmental Management*, *25*(6), 1363–1375. https://doi.org/10.1002/CSR.1645

Jové-Llopis, E., & Segarra-Blasco, A. (2018). Eco-innovation strategies: A panel data analysis of Spanish manufacturing firms. *Business Strategy and the Environment*, *27*(8), 1209–1220. https://doi.org/10.1002/bse.2063

Khan, M. (2020). CO_2 emissions and sustainable economic development: New evidence on the role of human capital. *Sustainable Development*, *28*(5), 1279–1288. https://doi.org/10.1002/SD.2083

10991719, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1002/sd.2541 by University Di Roma La Sapienza, Wiley Online Library on [14/03/2023]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Khan, Z., Ali, S., Umar, M., Kirikkaleli, D., & Jiao, Z. (2020). Consumption-based carbon emissions and international trade in G7 countries: The role of environmental innovation and renewable energy. *Science of the Total Environment*, *730*, 138945. https://doi.org/10.1016/J.SCITOTENV.2020.138945

Kiefer, C. P., González, P. D. R., & Carrillo-hermosilla, J. (2019). Drivers and barriers of eco-innovation types for sustainable transitions: A quantitative perspective. *Business Strategy and the Environment*, *28*(1), 155–172. https://doi.org/10.1002/BSE.2246

Koseoglu, A., Yucel, A. G., & Ulucak, R. (2022). Green innovation and ecological footprint relationship for a sustainable development: Evidence from top 20 green innovator countries. *Sustainable Development*, *30*, 976–988. https://doi.org/10.1002/SD.2294

Kwon, O. (2020). A study on how startups approach sustainable development through intellectual property. *Sustainable Development*, *28*(4), 613–625. https://doi.org/10.1002/SD.2012

Legewie, N. (2013). An introduction to applied data analysis with qualitative comparative analysis. *Forum Qualitative Sozialforschung/Forum: Qualitative Social Research*, *14*(3), 45. https://doi.org/10.17169/FQS-14.3.1961

Lessard, L. (2014). Designing and managing value co-creation in KIBS engagements. Technology innovation. *Management Review*, *4*(7), 36–43. www.timreview.ca

Lew, Y. K., & Park, J. Y. (2021). The evolution of N-helix of the regional innovation system: Implications for sustainability. *Sustainable Development*, *29*(2), 453–464. https://doi.org/10.1002/SD.2143

Li, J., Zhang, X., Ali, S., & Khan, Z. (2020). Eco-innovation and energy productivity: New determinants of renewable energy consumption. *Journal of Environmental Management*, *271*, 111028. https://doi.org/10.1016/J.JENVMAN.2020.111028

Liao, Z., Weng, C., & Shen, C. (2020). Can public surveillance promote corporate environmental innovation? The mediating role of environmental law enforcement. *Sustainable Development*, *28*(6), 1519–1527. https://doi.org/10.1002/SD.2101

Long, S., & Liao, Z. (2021). Are fiscal policy incentives effective in stimulating firms' eco-product innovation? The moderating role of dynamic capabilities. *Business Strategy and the Environment*, *30*(7), 3095–3104. https://doi.org/10.1002/BSE.2791

López-Rubio, P., Roig-Tierno, N., & Mas-Tur, A. (2021). A research journey from national systems of innovation to national systems of entrepreneurship: Introducing the sextuple helix. *International Journal of Innovation and Technology Management*, *18*(8), 1–23. https://doi.org/10.1142/S0219877021300081

Lu, J., Ren, L., Yao, S., Rong, D., Skare, M., & Streimikis, J. (2020). Renewable energy barriers and coping strategies: Evidence from the Baltic States. *Sustainable Development*, *28*(1), 352–367. https://doi.org/10.1002/SD.2030

Lucas, S. R., & Szatrowski, A. (2014). Qualitative comparative analysis in critical perspective. *Sociological Methodology*, *44*(1), 1–79. https://doi.org/10.1177/0081175014532763

Lundvall, B.-Å. (2016). *The learning economy and the economics of hope*. Anthem Press. https://doi.org/10.26530/OAPEN_626406

Marx, A., Cambré, B., & Rihoux, B. (2013). Crisp-set qualitative comparative analysis in organizational studies. In P. Fiss, B. Cambré, & A. Marx (Eds.), *Configurational theory and methods in organizational research* (pp. 23–47). Emerald Group Publishing.

Mas Verdú, F. (2021). Transferencia de conocimiento e intermediarios de innovación. *Papeles de Economía Española*, *169*, 104–118.

Mas-Verdu, F., Roig-Tierno, N., Nieto-Aleman, P. A., & Garcia-Alvarez-Coque, J.-M. (2020). Competitiveness in European regions and top-ranked universities: Do local universities matter? *Journal of Competitiveness*, *12*(4), 91–108. https://doi.org/10.7441/joc.2020.04.06

Mercado-Caruso, N., Segarra-Oña, M., Ovallos-Gazabon, D., & Peiró-Signes, A. (2020). Identifying endogenous and exogenous indicators to measure eco-innovation within clusters. *Sustainability*, *12*(15), 6088. https://doi.org/10.3390/SU12156088

Mieg, H. A. (2012). Sustainability and innovation in urban development: Concept and case. *Sustainable Development*, *20*(4), 251–263. https://doi.org/10.1002/SD.471

Milana, E., & Ulrich, F. (2022). Do open innovation practices in firms promote sustainability? *Sustainable Development*, *30*(6), 1718–1732. https://doi.org/10.1002/SD.2337

Miles, I. D., Belousova, V., & Chichkanov, N. (2018). Knowledge intensive business services: Ambiguities and continuities. *Foresight*, *20*(1), 1–26. https://doi.org/10.1108/FS-10-2017-0058/FULL/PDF

Miozzo, M., Desyllas, P., Lee, H. F., & Miles, I. (2016). Innovation collaboration and appropriability by knowledge-intensive business services firms. *Research Policy*, *45*(7), 1337–1351. https://doi.org/10.1016/J.RESPOL.2016.03.018

O'Brien, K., & Torugsa, N. (2011). Supply-side determinants of energy consumption and efficiency (ECE) innovations. *Journal of Business Chemistry*, *8*(3), 115–122.

OECD. (2010). *SMEs, entrepreneurship and innovation*. OECD.

Orlando, B., Ballestra, L. V., Scuotto, V., Pironti, M., & Giudice, M. d. (2020). The impact of R&D investments on eco-innovation: A cross-cultural perspective of green technology management. *IEEE Transactions on Engineering Management*, *69*(5), 2275–2284. https://doi.org/10.1109/TEM.2020.3005525

Păcesilă, M., & Ciocoiu, C. N. (2017). Systematic literature review on eco-innovation determinants. *Management Research and Practice*, *9*(3), 30–44. www.mrp.ase.ro

Pacheco, D. A. d. J., Caten, C. S. t., Jung, C. F., Navas, H. V. G., & Cruz-Machado, V. A. (2018). Eco-innovation determinants in manufacturing SMEs from emerging markets: Systematic literature review and challenges. *Journal of Engineering and Technology Management*, *48*, 44–63. https://doi.org/10.1016/J.JENGTECMAN.2018.04.002

Panapanaan, V., Uotila, T., & Jalkala, A. (2014). Creation and alignment of the eco-innovation strategy model to regional innovation strategy: A case from Lahti (Päijät-Häme region), Finland. *European Planning Studies*, *22*(6), 1212–1234. https://doi.org/10.1080/09654313.2013.774322

Park, H. W., & Stek, P. (2022). Measuring helix interactions in the context of economic development and public policies: From triple to quadruple and N-tuple helix vs. N-tuple and quadruple helix to triads. *Triple Helix*, *1*(aop), 1–11. https://doi.org/10.1163/21971927-BJA10026

Pereira, R. M., MacLennan, M. L. F., & Tiago, E. F. (2020). Interorganizational cooperation and eco-innovation: A literature review. *International Journal of Innovation Science*, *12*(5), 477–493. https://doi.org/10.1108/IJIS-01-2020-0008/FULL/PDF

Petruzzelli, A. M., Dangelico, R. M., Rotolo, D., & Albino, V. (2011). Innovation management, policy & practice organizational factors and technological features in the development of green innovations: Evidence from patent analysis. *Innovations*, *13*(3), 291–310. https://doi.org/10.5172/impp.2011.13.3.291

Porter, M. E., & van der Linde, C. (1995). Toward a new conception of the environment-competitiveness relationship. *Journal of Economic Perspectives*, *9*(4), 97–118.

Ragin, C. (1987). *The comparative method. Moving beyond qualitative and quantitative strategies*. University of California Press.

Ragin, C. (2008). *Redesigning social inquiry: Fuzzy sets and beyond*. University of Chicago Press.

Ragin, C. C. (2000). *Fuzzy-set social science*. University of Chicago Press.

Ragin, C. C. (2009). Chapter 5: Qualitative comparative analysis using fuzzy sets (fsQCA). In *Configurational comparative methods: Qualitative comparative analysis (QCA) and related techniques* (pp. 87–121). SAGE Publications.

Ragin, C. C. (2006). Set relations in social research: Evaluating their consistency and coverage. *Political Analysis*, *14*(3), 291–310. https://doi.org/10.1093/PAN/MPJ019

10991719, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1002/sd.2541 by University Di Roma La Sapienza, Wiley Online Library on [14/03/2023]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Reid, A., & Miedzinski, M. (2008). *Eco-innovation. Final report for sectoral innovation watch*. https://www.researchgate.net/publication/301520793_Eco-Innovation_Final_Report_for_Sectoral_Innovation_Watch

Rennings, K. (2000). Redefining innovation – Eco-innovation research and the contribution from ecological economics. *Ecological Economics*, *32*(2), 319–332. https://doi.org/10.1016/S0921-8009(99)00112-3

Reverte, C. (2022). The importance of institutional differences among countries in SDGs achievement: A cross-country empirical study. *Sustainable Development*, *30*(6), 1882–1899. https://doi.org/10.1002/SD.2354

Rihoux, B. (2006). Qualitative comparative analysis (QCA) and related systematic comparative methods: Recent advances and remaining challenges for social science research. *International Sociology*, *21*(5), 679–706. https://doi.org/10.1177/0268580906067836

Roig-Tierno, N., Gonzalez-Cruz, T. F., & Llopis-Martinez, J. (2017). An overview of qualitative comparative analysis: A bibliometric analysis. *Journal of Innovation & Knowledge*, *2*(1), 15–23. https://doi.org/10.1016/J.JIK.2016.12.002

Rosca, E., Reedy, J., & Bendul, J. C. (2018). Does frugal innovation enable sustainable development? A systematic literature review. *European Journal of Development Research*, *30*(1), 136–157. https://doi.org/10.1057/S41287-017-0106-3/TABLES/2

Sáez-Martínez, F. J., Díaz-García, C., & Gonzalez-Moreno, A. (2016). Firm technological trajectory as a driver ofeco-innovation in young small and medium-sized enterprises. *Journal of Cleaner Production*, *138*, 28–37. https://doi.org/10.1016/J.JCLEPRO.2016.04.108

Sánchez de la Vega, J. C., Buendía Azorín, J. D., Calvo-Flores Segura, A., & Esteban Yago, M. (2019). A new measure of regional competitiveness. *Applied Economic Analysis*, *27*(80), 108–126. https://doi.org/10.1108/AEA-07-2019-0010/FULL/PDF

Scarpellini, S. (2022). Social impacts of a circular business model: An approach from a sustainability accounting and reporting perspective. *Corporate Social Responsibility and Environmental Management*, *29*(3), 646–656. https://doi.org/10.1002/CSR.2226

Scarpellini, S., Ortega-Lapiedra, R., Marco-Fondevila, M., & Aranda-Usón, A. (2017). Human capital in the eco-innovative firms: A case study of eco-innovation projects. *International Journal of Entrepreneurial Behavior & Research*, *23*(6), 919–933. https://doi.org/10.1108/IJEBR-07-2017-0219

Scarpellini, S., Valero-Gil, J., Moneva, J. M., & Andreaus, M. (2020). Environmental management capabilities for a "circular eco-innovation". *Business Strategy and the Environment*, *29*(5), 1850–1864. https://doi.org/10.1002/BSE.2472

Schneider, C. Q., & Wagemann, C. (2012). *Set-theoretic methods for the social sciences: A guide to qualitative comparative analysis*. Cambridge University Press.

SCImago. (2022). *Institutions and university rankings*. Scimago. https://www.scimagoir.com/

Shou, Y., Shao, J., Lai, K., Kang, M., & Park, Y. (2019). The impact of sustainability and operations orientations on sustainable supply management and the triple bottom line. *Journal of Cleaner Production*, *240*, 118280. https://doi.org/10.1016/J.JCLEPRO.2019.118280

Smol, M., Kulczycka, J., & Avdiushchenko, A. (2017). Circular economy indicators in relation to eco-innovation in European regions. *Clean Technologies and Environmental Policy*, *19*(3), 669–678. https://doi.org/10.1007/s10098-016-1323-8

SolAbility. (2022). *The global sustainable competitiveness index*. SolAbility. https://solability.com/the-global-sustainable-competitiveness-index/the-index

Szutowski, D. (2021). The impact of eco-innovation on the stock returns of technology-based KIBS: Role of eco-innovation type and its degree of novelty. *Sustainability Accounting, Management and Policy Journal*, *12*(1), 130–155. https://doi.org/10.1108/SAMPJ-10-2019-0375/FULL/PDF

Tabrizian, S. (2019). Technological innovation to achieve sustainable development – Renewable energy technologies diffusion in developing countries. *Sustainable Development*, *27*(3), 537–544. https://doi.org/10.1002/SD.1918

Tao, R., Umar, M., Naseer, A., & Razi, U. (2021). The dynamic effect of eco-innovation and environmental taxes on carbon neutrality target in emerging seven (E7) economies. *Journal of Environmental Management*, *299*, 113525. https://doi.org/10.1016/J.JENVMAN.2021.113525

Tödtling, F., & Trippl, M. (2005). One size fits all?: Towards a differentiated regional innovation policy approach. *Research Policy*, *34*(8), 1203–1219. https://doi.org/10.1016/J.RESPOL.2005.01.018

Tsai, K. H., & Liao, Y. C. (2017). Innovation capacity and the implementation of eco-innovation: Toward a contingency perspective. *Business Strategy and the Environment*, *26*(7), 1000–1013. https://doi.org/10.1002/BSE.1963

Tur-Porcar, A., Mas-Tur, A., & Belso, J. A. (2017). Barriers to women entrepreneurship. Different methods, different results? *Quality and Quantity*, *51*(5), 2019–2034. https://doi.org/10.1007/S11135-016-0343-0/TABLES/6

Ukko, J., Saunila, M., Rantala, T., & Havukainen, J. (2019). Sustainable development: Implications and definition for open sustainability. *Sustainable Development*, *27*(3), 321–336. https://doi.org/10.1002/SD.1904

Vis, B. (2012). The comparative advantages of fsQCA and regression analysis for moderately large-N analyses. *Sociological Methods & Research*, *40*(1), 168–198. https://doi.org/10.1177/0049124112442142

Wagemann, C., & Schneider, C. Q. (2010). Qualitative comparative analysis (QCA) and fuzzy-sets: Agenda for a research approach and a data analysis technique. *Comparative Sociology*, *9*(3), 376–396. https://doi.org/10.1163/156913210X12493538729838

Zhen, H. (2011). Research on the evaluation of China's provincial eco-innovation capability. *Energy Procedia*, *5*, 647–653. https://doi.org/10.1016/J.EGYPRO.2011.03.114

Zubeltzu-Jaka, E., Erauskin-Tolosa, A., & Heras-Saizarbitoria, I. (2018). Shedding light on the determinants of eco-innovation: A meta-analytic study. *Business Strategy and the Environment*, *27*(7), 1093–1103. https://doi.org/10.1002/bse.2054

How to cite this article: Chaparro-Banegas, N., Mas-Tur, A., Park, H. W., & Roig-Tierno, N. (2023). Factors driving national eco-innovation: New routes to sustainable development. *Sustainable Development*, 1–15. https://doi.org/10.1002/sd.2541

10991719, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1002/sd.2541 by University Di Roma La Sapienza, Wiley Online Library on [14/03/2023]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License