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**ECO-INNOVATION AS A KEY DRIVER
FOR SUSTAINABLE GROWTH AND DEVELOPMENT:
THE CASE OF EUROPEAN UNION COUNTRIES**

Abstract: Globalization, technological advancement, and environmental degradation are the main forces behind the growth of eco-innovation. Along with minimizing adverse effects on the environment and making efficient utilization of natural resources, eco-innovation is also closely tied to the goals regarding sustainable growth and development. Eco-innovation needs to be systematically measured to track advancements made towards a more sustainable future. The creation of metrics and techniques for measuring eco-innovation is a significant theoretical and practical problem. The current state of eco-innovation measurement methods is such that a cross-national comparative analysis is challenging. The objective of this paper is to perform a comparative examination of the eco-innovation performance in European Union countries as a key driver of sustainable growth and development. The research employs a comparative assessment and synthesis approach founded on the Eco-Innovation Index in addition to a critical assessment of scholarly literature. Creating and implementing eco-innovation performances in EU countries should be given top priority to promote future sustainable growth and development.

Keywords: eco-innovation; key driver; sustainable growth and development; eco-innovation index; European Union countries.

Introduction

A key strategy for increasing countries' competitiveness and guaranteeing more sustainable growth and development is eco-innovation, which is one of the top areas of the innovation framework^{1,2,3,4}. The opportunities for eco-innovation need to be explored on a worldwide, regional, national, and local scale. It is also essential for the policies of the European Union to appropriately formulate policy

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¹ **Ekins, P.** Eco-innovation for environmental sustainability: concepts, progress and policies. *International Economics and Economic Policy*, vol. 7(2-3), 2010, pp. 267-290.

² **Urbaniec, M. et. al.** Measurements and Trends in Technological Eco-Innovation: Evidence from Environment-Related Patents. *Resources*, vol.10, 2021, pp. 1-17.

³ **Horbach, J.** Empirical determinants of eco-innovation in European countries using the community innovation survey. *Environmental Innovation and Societal Transitions*, vol. 19, 2016, pp. 1-14.

⁴ **Terzić, L.** The green and digital transition through innovation, SME competitiveness, and economic resilience: Evidence from the European Union economies. *Journal of Theoretical and Applied Economics*, Vol. XXX, No. 2(635), 2023b, pp. 43-62.

in this domain and to assess the degree of innovation while considering its diversified factors. The paper reveals a comprehension of the significant eco-innovation tendencies by employing the Eco-Innovation Index (EII) methodology to assess many aspects of the EU countries' eco-innovation performance. As one of the three components of environmental sustainability (along with infrastructure and the manufacturing sector) that are specifically referred to in SDG 9, eco-innovation, in particular, and innovation overall both contribute to the accomplishment of the 2030 Agenda for Sustainable Development Objectives. Furthermore, they perform accordingly by offering scientific and technological alternatives to the obstacles presented by the other Sustainable Development Goals^{5,6}.

Eco-innovation is especially vital to achieving sustainable growth and development, which is recognized as a fundamental component of renewable energy policies and initiatives as well as a driver of such adjustments^{7,8,9}. Minimizing adverse environmental effects and developing new markets for goods, services, or procedures aimed at enhancing the environment's sustainability (e.g., conserving energy as well as other assets and cutting down on pollution) are the main goals of eco-innovation¹⁰. Sustainable innovation is a kind of invention that can have a major positive influence on the environment while simultaneously helping both companies and consumers. Eco-innovation is either a newly developed or greatly enhanced method, item, organizational modification, or marketing strategy that

⁵ **Becker, W. et. al.** Exploring the link between Asia and Europe connectivity and sustainable development. *Research in Globalization*, vol. 3, 2021,100045.

⁶ **United Nations.** *The Sustainable Development Goals Report 2022*. Cambridge University Press, 2022.

⁷ **Díaz-García, C., González-Moreno, Á., Sáez-Martínez, F. J.** Eco-innovation: insights from a literature review. *Innovation*, vol. 17, 2015, pp. 6-23.

⁸ **Cai, W., Li, G.** The drivers of eco-innovation and its impact on performance: Evidence from China. *Journal of Cleaner Production*, vol. 176, 2018, pp.110-118.

⁹ **Colombo, A., Owen, R., Pansera, M.** The Discourse of Eco-innovation in the European Union: An Analysis of the Eco-Innovation Action Plan and Horizon 2020. *Journal of Cleaner Production*, vol. 214(20), 2018, pp. 653-665.

¹⁰ **OECD.** *OECD Environmental Outlook to 2050: The Consequences of Inaction*, OECD: Paris, 2012.

lowers the release of dangerous materials along the course of their entire life cycle^{11,12,13}.

Eco-innovation is consequently a crucial component of corporate competitiveness and has a direct impact on economic benefits; nevertheless, its application and size are dependent on a variety of factors, including the industry, rules and regulations, customer sensitivity, and environmental consciousness. The deployment of these measures seeks to enhance competitiveness by lowering energy and material costs while simultaneously mitigating adverse environmental effects^{14,15,16,17,18}. While the literature offers numerous interpretations, a single definition of eco-innovation is an innovation that improves the quality of the environment and is applied to enhance a company's ecological sustainability^{19,20}. Even with the increased attention, there is still not much research done in the field

¹¹ **Kemp, R., Foxon, T.** *Eco-Innovation from an Innovation Dynamics Perspective*. Deliverable 1 of MEI project (D1), Maastricht, 6, 2007, pp. 25.

¹² **OECD.** *OECD Environmental Outlook to 2050: The Consequences of Inaction*, OECD: Paris, 2012.

¹³ **Donis, S., Gomez, J., Salazar, I.** *The determinants of eco-innovation at the country level. An analysis for OECD countries. VIII Workshop de Jóvenes investigadores en Economía y Empresa*. Universidad de Zaragoza, 16562, 2021.

¹⁴ **Porter, E., Van Der Linde, C.** Toward a new conception of the environment: Competitiveness relationship. *Journal of Economic Perspectives*, vol. 9, 1995, pp. 97-118.

¹⁵ **EPI.** *Environmental Performance Index 2018*. New Haven: Yale University, 2018. [online] [Accessed: 27 December 2021]. Available at <https://epi.yale.edu/downloads/epi2018policymakerssummaryv01.pdf>

¹⁶ **Horbach, J., Rammer, C., Rennings, K.** Determinants of eco-innovations by type of environmental impact – The role of regulatory push/pull, technology push and market pull. *Ecological Economics*, vol. 78, 2012, pp. 112-122.

¹⁷ **Nordhaus, W.** *The Spirit of Green: The Economics of Collisions and Contagions in a Crowded World*. Princeton NJ: Princeton University Press, 2021.

¹⁸ **Terzić, L.** The green and digital transition through innovation, SME competitiveness, and economic resilience: Evidence from the European Union economies. *Journal of Theoretical and Applied Economics*, Vol. XXX, No. 2(635), 2023b, pp. 43-62.

¹⁹ **Díaz-García, C., González-Moreno, Á., Sáez-Martínez, J.** Eco-innovation: insights from a literature review. *Innovation*, vol. 17, 2015, pp. 6-23

²⁰ **Park, S. et al.** Eco-Innovation Indices as Tools for Measuring Sustainability. *Sustainability*, vol. 9, 2017, pp. 1-28.

of eco-innovation. Primarily, it is devoid of a generally acknowledged definition and a logical theoretical framework^{21,22,23,24}.

Additionally, quantifying the impacts of eco-innovation lacks a standardized methodology. Conversely, regional and national differences exist in the quantity and caliber of data regarding the environment. When discussing eco-innovation at the macroeconomic level, it is important to note that several theoretical frameworks, such as those specific to European nations, are used in the real world and in the literature to measure and analyze eco-innovation. This is associated with nations' endeavors to attain sustainable growth, in addition to mitigating adverse environmental effects and optimizing the utilization of natural resources. Eco-innovation must be systematically measured to track advancements toward a more sustainable future^{25,26}. Thus creating techniques and metrics to assess and evaluate eco-innovation at the macro and micro stages.

The purpose of this paper is to provide an analytical comparison of the evolution of eco-innovation in European Union countries. Which eco-innovation advancements or challenges are present in a subset of European nations is the primary study issue. A critical examination of the literature and an examination of the comparison and synthesis procedures founded on the Eco-Innovation Index were the methods employed. Implementing a comparable methodology, this paper offers a comprehensive summary of the advancements in eco-innovation progress.

²¹ **Türkeli, S., and Kemp, R.** Changing Patterns in Eco-Innovation Research: A Bibliometric Analysis. In: Horbach, J. & Reif, C. (Eds.). *New Developments in Eco-Innovation Research*. Cham: Springer International Publishing, 2018.

²² **Urbaniec, M. et. al.** Measurements and Trends in Technological Eco-Innovation: Evidence from Environment-Related Patents. *Resources*, vol.10, 2021, pp. 1-17.

²³ **Terzić, L.** Unveiling the Linkages between Economic Complexity, Innovation and Growth: The Case of High-Income and Upper Middle-Income Economies. *Scientific Annals of Economics and Business*, 69(3), 2022a, pp. 477–500.

²⁴ **Terzić, L.** The green and digital transition through innovation, SME competitiveness, and economic resilience: Evidence from the European Union economies. *Journal of Theoretical and Applied Economics*, Vol. XXX, No. 2(635), 2023b, pp. 43-62.

²⁵ **Park, S. et al.** Eco-Innovation Indices as Tools for Measuring Sustainability. *Sustainability*, vol. 9, 2017, pp. 1-28.

²⁶ **Terzić, L.** The green and digital transition through innovation, SME competitiveness, and economic resilience: Evidence from the European Union economies. *Journal of Theoretical and Applied Economics*, Vol. XXX, No. 2(635), 2023b, pp. 43-62.

By examining the factors that influence eco-innovation in various nations, the investigation adds to the repository of knowledge on assessing eco-innovation achievement. The structure of the article operates as follows: The study's introduction is covered in the first section. A theoretical overview of the scientific literature is provided in the second section of the paper. In Section 3, research methodology and data, including the conceptual structure for gauging eco-innovation, are presented. The findings of the study examination are given in the fourth section of the paper, with an emphasis on how far EU economies have come in terms of eco-innovation. The findings are given in the fifth section.

Theoretical overview of the literature

There are numerous theoretical perspectives on eco-innovation. Scientific research contains a single, broadly agreed term for eco-innovation, and the theories that are currently in use have different purviews for research^{27,28,29,30}. Compared to conventional innovation, eco-innovation is characterized by a significantly higher degree of variance because its outcomes are typically indecisive and it frequently depends on scientific procedures (sustainability solutions). The extent and level of information in the various explanations for eco-innovation found in academic research and economic implementation differ. Overall, they are interested in inventions that improve sustainability.

²⁷ **Díaz-García, C., González-Moreno, Á., Sáez-Martínez, J.** Eco-innovation: insights from a literature review. *Innovation*, vol. 17, 2015, pp. 6-23.

²⁸ **Ghisetti, C., Marzucchi, A., and Montresor, S.** The open eco-innovation mode. An empirical investigation of eleven European countries. *Research Policy*, vol. 44(5), 2015, pp. 1080-1093.

²⁹ **Türkeli, S., and Kemp, R.** Changing Patterns in Eco-Innovation Research: A Bibliometric Analysis. In: Horbach, J. & Reif, C. (Eds.). *New Developments in Eco-Innovation Research*. Cham: Springer International Publishing, 2018.

³⁰ **Terzić, L.** Why is the transition to a green economy important for achieving sustainability? A review of some theoretical approaches and empirical research presented in the literature. *Economic Thought Journal*, vol. 68(3), 2023a, pp. 307-332.

Researchers began examining eco-innovation as early as the end of the 1970s³¹. In the latter period, the 1990s, a more comprehensive definition of eco-innovation was developed, encompassing "all of the gauges involving appropriate performers (companies, legislators, organizations, groups, religious organizations, and private households) that; create novel concepts, actions, goods, or procedures, utilize or present themselves, and that help achieve the minimization of worldwide environmental demands or environmentally friendly defined sustainability goals"^{32,33}. Eco-innovation encompasses improvements in institutional and social frameworks in addition to advances in goods, procedures, and advertising approaches. Thus, eco-innovation need not always be a worldwide first or the outcome of a purposeful commercial endeavor or plan.

Accordingly, it could be claimed that every invention that outperforms important possibilities in terms of environmental advantages is an eco-innovation (e.g., sustainability technologies, organizational innovations, goods and services, innovations, and green framework technological advances)^{34,35,36,37}. A comparable approach has been applied to the Eco-Innovation Scoreboard (Eco-IS). Designed to minimize negative environmental effects or achieve greater effectiveness and environmentally conscious utilization of resources, eco-innovation has been defined by the EIO as every type of invention that makes a tangible advancement regarding the ultimate objective of sustainable growth. This includes the planned and unplanned environmental effects of new ideas, in addition to green technology systems, procedures, and solutions. The eco-

³¹ **Urbaniec, M.** Towards Sustainable Development through Eco-innovations: Drivers and Barriers in Poland, *Economics and Sociology*, vol. 8(4), 2015, pp.179-190.

³² **Rennings, K.** Redefining innovation – eco-innovation research and the contribution from ecological economics. *Ecological economics*, vol. 32, 2000, pp. 319-332.

³³ **United Nations.** *The Sustainable Development Goals Report 2022*. Cambridge University Press, 2022.

³⁴ **Arundel, A., Kemp, R.** *Measuring eco-innovation*. Working Paper Series. UNU-MERIT, 2009.

³⁵ **Ghisetti, C., Marzucchi, A., Montresor, S.** The open eco-innovation mode. An empirical investigation of eleven European countries. *Research Policy*, vol. 44(5), 2015, pp. 1080-1093.

³⁶ **OECD.** *OECD Environmental Outlook to 2050: The Consequences of Inaction*, OECD: Paris, 2012.

³⁷ **Nordhaus, W.** *The Spirit of Green: The Economics of Collisions and Contagions in a Crowded World*. Princeton NJ: Princeton University Press, 2021.

innovation achievements of the EU countries are summarized by the Eco-Innovation Scoreboard (Eco-IS). Utilizing sixteen variables categorized into 5 dimensions—eco-innovation inputs, eco-innovation activities, eco-innovation outputs, resource effectiveness results, and socioeconomic performance—it seeks to quantify various elements of eco-innovation^{38,39}. The positive and negative aspects of eco-innovation across every EU nation can be determined according to the Eco-Innovation Scoreboard rating. The Eco-Innovation Scoreboard enhances other methods of gauging national innovation, including the International Innovation Index⁴⁰, by advocating for a comprehensive understanding of economic, ecological, and social achievements.

As a result, the Eco-Innovation Index is the basis for the parameters that this research analyzes for European nations^{41,42,43}. The Eco-Innovation Index allows for the examination of a country's shortcomings and opportunities by displaying how well that nation is doing across a range of eco-innovation aspects. The goal of the Eco-Innovation Index is to advance an integrated perspective on economic, social, and environmental sustainability. Numerous academics have focused on creating a study approach to quantify eco-innovation^{44,45,46}. This adds

³⁸ **Colombo, A., Owen, R., Pansera, M.** The Discourse of Eco-innovation in the European Union: An Analysis of the Eco-Innovation Action Plan and Horizon 2020. *Journal of Cleaner Production*, vol. 214(20), 2018, pp. 653-665.

³⁹ **Terzić, L.** Towards European Union's Green Deal: The Importance of Sustainable Competitiveness and Eco-Innovation for Achieving Prosperity in the EU-27 Member States. *International Journal of Economics and Innovation*, vol. 8(2), 2022b, pp. 195-218.

⁴⁰ **European Commission.** *Eco-innovation at the heart of European policies*. European Commission, Directorate-General for Environment, 2022. [online] [Accessed: 27 December 2023]. Available at https://green-business.ec.europa.eu/eco-innovation_en

⁴¹ **EIO.** *Europe in transition: Paving the way to a green economy through eco-innovation*. Brussels: DG Environment, 2013.

⁴² **Jo, J.-H. et al.** Eco-Innovation for Sustainability: Evidence from 49 Countries in Asia and Europe. *Sustainability*, vol. 7, 2015, pp. 1-16.

⁴³ **Park, S. et al.** Eco-Innovation Indices as Tools for Measuring Sustainability. *Sustainability*, vol. 9, 2017, pp. 1-28.

⁴⁴ **Horbach, J., Rammer, C., Rennings, K.** Determinants of eco-innovations by type of environmental impact – The role of regulatory push/pull, technology push and market pull. *Ecological Economics*, vol. 78, 2012, pp. 112-122.

⁴⁵ **Horbach, J.** Empirical determinants of eco-innovation in European countries using the community innovation survey. *Environmental Innovation and Societal Transitions*, vol. 19, 2016, pp. 1-14.

⁴⁶ **Terzić, L.** Towards European Union's Green Deal: The Importance of Sustainable Competitiveness and Eco-Innovation for Achieving Prosperity in the EU-27 Member States. *International Journal of Economics and Innovation*, vol. 8(2), 2022b, pp. 195-218.

to the attempt to discover novel approaches to assessment in the field of economics. Though most research has been done in industrialized nations (i.e., European nations), very few studies have looked at eco-innovation at the national level⁴⁷.

Simultaneously, numerous scholars highlight the connection between innovation and countries' competitiveness, contending that innovations boost competitiveness by allowing businesses to quickly adjust to the rate of technological advancement and changing market conditions^{48, 49, 50, 51, 52, 53}. This allows businesses to obtain a competitive edge and boost economic competitiveness^{54, 55, 56, 57}. Figure 1 presents opportunities for eco-innovation through a summary of risk factors, regulatory pressures, and changing market conditions.

⁴⁷ **Jo, J.-H. et al.** Eco-Innovation for Sustainability: Evidence from 49 Countries in Asia and Europe. *Sustainability*, vol. 7, 2015, pp. 1-16.

⁴⁸ **Baumol, J.** *The Free-Market Innovation Machine - Analysing the Growth Miracle of Capitalism*. New Jersey: Princeton University Press, 2002

⁴⁹ **Constantini, V., Mazzanti, M.** On the green and innovative side of trade competitiveness? The impact of environmental policies and innovation on EU exports. *Research Policy*, vol. 41(1), 2012, pp. 132-153. <https://doi.org/10.1016/j.respol.2011.08.004>

⁵⁰ **Bugnar, G., Mester E., Fora, F.** Innovation and International Competitiveness of a Country. *Annals of Faculty of Economics*, vol. 1(2), 2016, pp. 35-43.

⁵¹ **Peretto, F.** From Smith to Schumpeter: A Theory of Take-off and Convergence to Sustained Growth. *European Economic Review*, vol. 78, 2015, pp. 1-26.

⁵² **Terzić, L.** Unveiling the Linkages between Economic Complexity, Innovation and Growth: The Case of High-Income and Upper Middle-Income Economies. *Scientific Annals of Economics and Business*, 69(3), 2022a, pp. 477-500.

⁵³ **Terzić, L.** Why is the transition to a green economy important for achieving sustainability? A review of some theoretical approaches and empirical research presented in the literature. *Economic Thought Journal*, vol. 68(3), 2023a, pp. 307-332.

⁵⁴ **Atkinson, R., Ezell, S.** *Innovation Economic: The Race for Global Advantage*. London: Yale University Press, 2012.

⁵⁵ **Ciocanel, B., Pavelescu, M.** Innovation and competitiveness in European context. *Procedia Economics and Finance*, vol. 32, 2015, pp. 728-737.

⁵⁶ **Dutta, S., Lanvin, B., Wunsch-Vincent, S.** *The Global Innovation Index 2019: Creating Healthy Lives – The Future of Medical Innovation, Ithaca, Fontainebleau, and Geneva*. Geneva: World Intellectual Property Organization, 2019.

⁵⁷ **Terzić, L.** Towards European Union's Green Deal: The Importance of Sustainable Competitiveness and Eco-Innovation for Achieving Prosperity in the EU-27 Member States. *International Journal of Economics and Innovation*, vol. 8(2), 2022b, pp. 195-218.

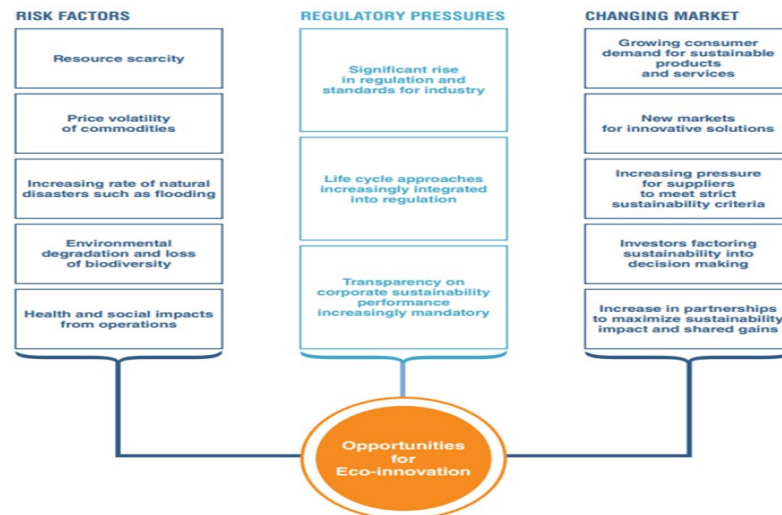


Figure 1. *Opportunities for Eco-Innovation – A summary of risk factors, regulatory pressures, and changing market conditions*

Given this discrepancy in research, comparing the degree of eco-innovation in Europe may be possible by concentrating on eco-innovation and employing the methods employed in the Eco-Innovation Ranking. It is evident from the literature assessment on theoretical methods to determine and evaluate the consequences of eco-innovation that, currently, there is no standard gauge or approach to evaluation. Due to the approaches' complexity and amount of information, the specific instance must be appropriately adapted. On the other hand, it needs to guarantee that the outcomes of eco-innovation initiatives are comparable. Another factor contributing to the challenge of quantifying eco-innovation outcomes is their association with unpredictability. Policies regarding the environment can be promoted and worldwide comparisons established by assessing eco-innovation at the national level. Eco-innovation opportunities are especially crucial for developing and putting into practice tools to promote environmental sustainability^{58, 59}.

⁵⁸ Donis, S., Gomez, J., Salazar, I. *The determinants of eco-innovation at the country level. An analysis for OECD countries. VIII Workshop de Jóvenes investigadores en Economía y Empresa.* Universidad de Zaragoza, 16562, 2021.

⁵⁹ Terzić, L. The green and digital transition through innovation, SME competitiveness, and economic resilience: Evidence from the European Union economies. *Journal of Theoretical and Applied Economics*, Vol. XXX, No. 2(635), 2023b, pp. 43-62.

Assessing eco-innovation also helps to increase awareness among people of responsibility for the environment and improves our comprehension of broader sustainable issues. As previously stated, there are obstacles to the adoption of eco-innovations, mostly because organizational changes are required, ranging from leadership styles to manufacturing processes. Additionally, it is an enormous chance but comes with risks and expenses^{60,61}, which limits the potential of implementing "extreme" eco-innovations^{62,63}. It needs labor and financial resources without an assurance of profit. Internally, organizational environment obstacles, including technical knowledge, governance of the environment, and accessible funding, have been identified in the literature. Furthermore, the company faces external obstacles related to the ecosystem it performs in, such as the accessibility of suppliers and funding from governments^{64,65,66}.

The Sustainable Development Goals (SDGs) are related to the Eco-Innovation Scoreboard. "Eco-industries" are the subject of the socio-economic outcomes elements, which include indicators of export of goods from eco-industries, employment in eco-industries, and turnover in eco-industries. SDG 9: Industry and Infrastructure emphasize that eco-industries may support inclusive, environmentally sustainable industrialization, innovation, and the development of resilient infrastructure. They support productive employment and growth that is

⁶⁰ **Porter, E., Van Der Linde, C.** Toward a new conception of the environment: Competitiveness relationship. *Journal of Economic Perspectives*, vol. 9, 1995, pp. 97-118.

⁶¹ **European Commission.** *Eco-innovation at the heart of European policies*. European Commission, Directorate-General for Environment, 2022. [online] [Accessed: 27 December 2023]. Available at https://green-business.ec.europa.eu/eco-innovation_en

⁶² **Hazarika, N., Zhang, X.** Evolving theories of eco-innovation: A systematic review. *Sustainable Production and Consumption*, 19, 2019, pp. 64-78.

⁶³ **Bugnar, G., Mester E., Fora, F.** Innovation and International Competitiveness of a Country. *Annals of Faculty of Economics*, vol. 1(2), 2016, pp. 35-43.

⁶⁴ **Kiefer, C. P., Del Río González, P., Carrillo-Hermosilla, J.** Drivers and barriers of eco-innovation types for sustainable transitions: A quantitative perspective. *Business Strategy and the Environment*, vol. 28(1), 2019, pp. 155-172.

⁶⁵ **European Commission.** *Eco-innovation at the heart of European policies*. European Commission, Directorate-General for Environment, 2022. [online] [Accessed: 27 December 2023]. Available at https://green-business.ec.europa.eu/eco-innovation_en

⁶⁶ **European Environment Agency.** *Eco-innovation Scoreboard*. Publications Office of the European Union, 2023. [online][Accessed: 27 December 2023]. Available at https://green-business.ec.europa.eu/index_en

sustainable (SDG 8: Good Jobs and Economic Growth). The resource-use component of eco-innovation is the main emphasis of the Eco-IS. One of the main components of eco-innovation is resource efficiency. Decreasing resource consumption, as demonstrated by indicators of lowering material input and lowering energy input, is how eco-innovation activities are quantified. It makes sustainable production processes and industrialization (SDG 9: Industry and Infrastructure) easier.

Data and research methodology

The data sources utilized for generating the parameters include the European Eco-Innovation Observatory Scoreboard, the European Commission countries database, and many international and scientific communities. The research investigation uses a critical evaluation of the scientific literature along with a comparative analysis and synthesis method based on the Eco-Innovation Index. Table 1 presents a synopsis of Eco-innovation components linked to Sustainable Development Goals (SDGs).

Table 1. *Synopsis of Eco-innovation components linked to Sustainable Development Goals*

Component of eco-innovation	Parameter	Sustainable Development Goals SDGs
Eco-Innovation Inputs	Governments environmental and energy R&D appropriations and outlays; Total R&D personnel and researchers; Total value of green early-stage investments	SDG 9 Industry and Infrastructure; SDG 12 Sustainable consumption and production
Eco-innovation activities	Firms having implemented innovation activities aiming at a reduction of material input per unit output; Firms having implemented innovation activities aiming at a reduction of energy input per unit output; ISO 14001 registered organizations	SDG 12 Sustainable consumption and production; SDG 8 Good jobs and economic growth; SDG 9 Industry and Infrastructure

Eco-innovation outputs	Eco-innovation related patents; Eco-innovation related academic publications; Eco-innovation related media coverage	SDG 9 Industry and Infrastructure; SDG 12 Sustainable consumption and production; SDG 8 Good jobs and economic growth
Resource-efficiency outcomes	Material productivity; Water productivity; Energy Productivity; GHG emissions intensity	SDG 3 Good health; SDG 12 Sustainable consumption and production; SDG 6 Clean water; SDG 7 Clean energy; SDG 13 Climate action
Socio-economic outcomes	Exports of products from eco-industries; Employment in eco-industries; Turnover in eco-industries	SDG 9 Industry and Infrastructure; SDG 12 Sustainable consumption and production; SDG 8 Good jobs and economic growth

Source: Summarization by the author based on the European Eco-Innovation Scoreboard 2021-2022. and United Nations (2022). *The Sustainable Development Goals Report 2022*.

The research employed data collected from 2021 to 2022 to summarize the Eco-Innovation Index, as well as the evolution of the eco-innovation indices from the 2013-2022 period. The environment, economy, and social dimensions are all included in the Eco-Innovation Index. As a result, a thorough instrument was created to gauge eco-innovation in nations that are EU members. Furthermore, according to the European Commission, the Eco-Innovation Index comprises output-oriented variables that evaluate the outcomes of inventive operations as well as input-based variables that measure the expenditures of creative operations. According to Park et al. it is also essential to incorporate the influence of eco-innovation into the Eco-Innovation Index. There are distinct parameters in the Eco-Innovation indices that are arranged into five categories⁶⁷.

The goal of the European Green Deal is to move toward an environmentally conscious and zero-carbon economy, and eco-innovation is essential to accomplishing this goal. According to the European Commission's eco-innovation index, the EU had a rise in eco-innovation between 2013 and 2022.

⁶⁷ **European Commission.** *Eco-innovation at the heart of European policies*. European Commission, Directorate-General for Environment, 2022. [online] [Accessed: 27 December 2023]. Available at https://green-business.ec.europa.eu/eco-innovation_en

The key reason why this happened was the increased efficiency of resources. It is anticipated that this gradual rise will continue because the European Green Deal has set high goals about sustainability and environmental conditions, and the activities that go along with it will probably foster an environment that is conducive to greater eco-innovation.

Research results

The research examination was performed in the European Union Member States: Sweden, Spain, Slovenia, Slovakia, Romania, Portugal, Poland, the Netherlands, Malta, Luxembourg, Lithuania, Latvia, Italy, Ireland, Hungary, Greece, Germany, France, Finland, Estonia, Denmark, Czechia, Cyprus, Croatia, Bulgaria, Belgium, and Austria. The collected data for every member state covers the period 2021–2022, and the evolution of the eco-innovation period for the 2013-2022 period. The following Figure 2 presents the position and accomplishments of EU Member States for the base year of 2021 using various parameters in the Eco-Innovation Index 2022.

There are common obstacles to eco-innovation faced by all EU members, and decision-makers must carefully consider these constraints to employ appropriate and successful strategies and tools for eco-innovation policy. The Eco-Innovation Leaders in Europe for the year 2021-2022 period are, in decreasing order of econ-innovation scores, Luxembourg (179.02), Finland (178.01), Austria (173.86), Denmark (167.49), Sweden (160.95), Germany (141.18), France (130.65), Italy (129.39), and the Netherlands (118.78), as shown in Figure 2. Average Eco-Innovation performers are, in descending order, Spain (116.43), Slovenia (115.86), Estonia (115.52), the Czech Republic (110.98), Ireland (110.39), Portugal (105.69), Latvia (105.37), Lithuania (103.75), and Greece (101.59).

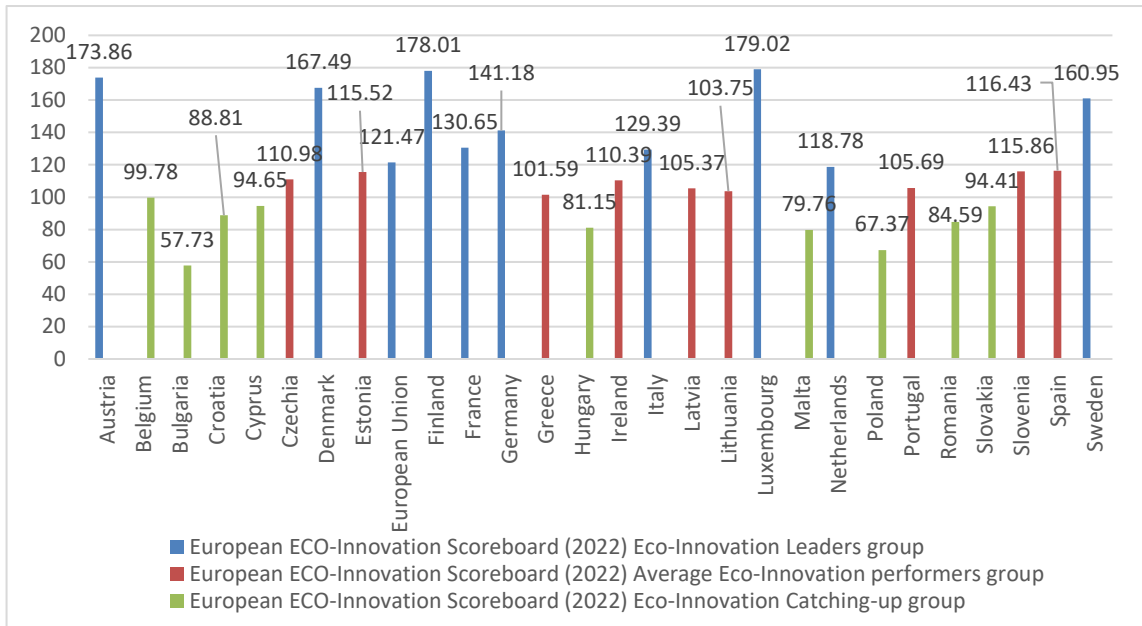


Figure 2. *Eco-Innovation Index in the EU countries for 2021-2022*

Source: Derived from the author based on the European Eco-Innovation Scoreboard 2021-2022.

The eco-innovation performance of the most Eco-Innovation Leaders group is under the EU-27 average score, as shown in Figure 2. Member States in the category of catching up with eco-innovation include, on a decreasing scale, Belgium (99.78), Cyprus (94.65), Slovakia (94.41), Croatia (88.81), Romania (84.59), Hungary (81.15), Malta (79.76), Poland (67.37), and Bulgaria (57.73). Examining how the Eco-Innovation Index has changed over the past ten years within the framework of European Member States is crucial to improving our comprehension of Europe's development. Showing how the eco-innovation indicators have changed over time is also essential for determining which sectors still need work and funding. The graph below shows the evolution of the combined Eco-Innovation Index and indices for every country that is part of the EU throughout the previous ten years, from 2013 to 2022.

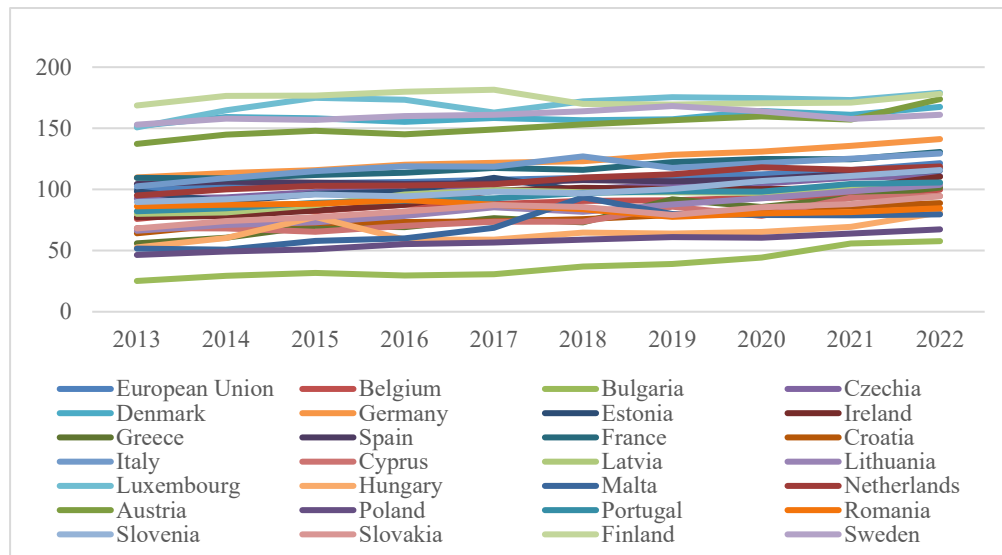


Figure 3. *Evolution of the Eco-Innovation Index in the EU countries for 2013-2022*

Source: Derived from the author based on the European Eco-Innovation Scoreboard 2013-2022.

Greece, Lithuania, Austria, Ireland, Bulgaria, and Germany are the Member States that show the most increase in their eco-innovation scores between 2013 and 2022, in descending order. For EU nations in this category, eco-innovation performance in comparison to 2021 has increased for Ireland and Greece. As shown in Figure 3, the change in each of these nations' Eco-Innovation Indexes is equivalent to at least 30 points. Austria has improved the most compared to 2021, followed by France Sweden, Finland, and Spain had the lowest changes in the Eco-Innovation Index between 2013 and 2022. Despite this slight improvement, Sweden and Finland continue to be among the top nations in terms of eco-innovation. The ten-year trend in the scores of member states that are catching up with eco-innovation is always changing. Bulgaria, Malta, and Hungary show the most improvements between 2013 and 2022, as seen in Figure 3. Starting in 2016, Romania's performance has continued to decrease. The European Innovation Index (EIS) is an annual assessment that contrasts the accomplishments of research and innovation ecosystems in EU nations and select third-country settings, along with the respective benefits and drawbacks of each nation.

The following approach, which consists of the Eco-Innovation Scoreboard in addition to the Index, measures 16 distinct parameters that are divided into five main categories to quantify the various facets of the eco-innovations made by each of the member states: Eco-innovation inputs (government expenditures and investments related to renewable energy, the overall number of R&D employees, etc.); Eco-innovation initiatives (such as the quantity of ISO 14001 licenses held by small and medium-sized businesses, the adoption of sustainable goods, etc.); Eco-innovation outputs (such as media coverage, scholarly articles, and patents about sustainable development); Resource efficiency (which includes productivity of materials, water, and energy as well as the intensity, and socio-economic outcomes (e.g., percentage of employment in environmental protection, export of goods from sustainable industries, etc.)). The Eco-Innovation Scoreboard (Eco-IS) compares the total achievements of EU countries to an European mean of 100, showing their advantages (index>100), vulnerabilities (index <100), and overall accomplishments.

The starting point for evaluating the impacts of eco-innovation initiatives and eco-policies, with necessary lags, is provided by the environmental indices. Eco-policies measurements are necessary to ascertain how policies impact sustainability through eco-innovation and to pinpoint policy shortcomings where further action is required. The fourth class of indicators is socio-economic well-being variables. These gauges do not address the innovation-outcome cycle, but they can be very helpful in preventing unfavorable consequences like increased inequality from emerging from the transition to sustainable economic growth. The eco-innovation input scores of EU nations are shown in Figure 4. According to the eco-innovation input values, the leading EU countries are Germany (159.83), Finland (155.07), France (149.54), Denmark (145.35), Austria (141.89), Sweden (135.27), Italy (109.69), the Netherlands (93.88), and Luxembourg (89.65), as shown in Figure 4. The scores of the Eco-innovation input revealed enormous gaps between EU countries. The Eco-innovation input score in Germany, as the

leader in the observed period, was almost eleven times higher than in Cyprus (the indicator score was 14.96), which ranked last among the EU countries.

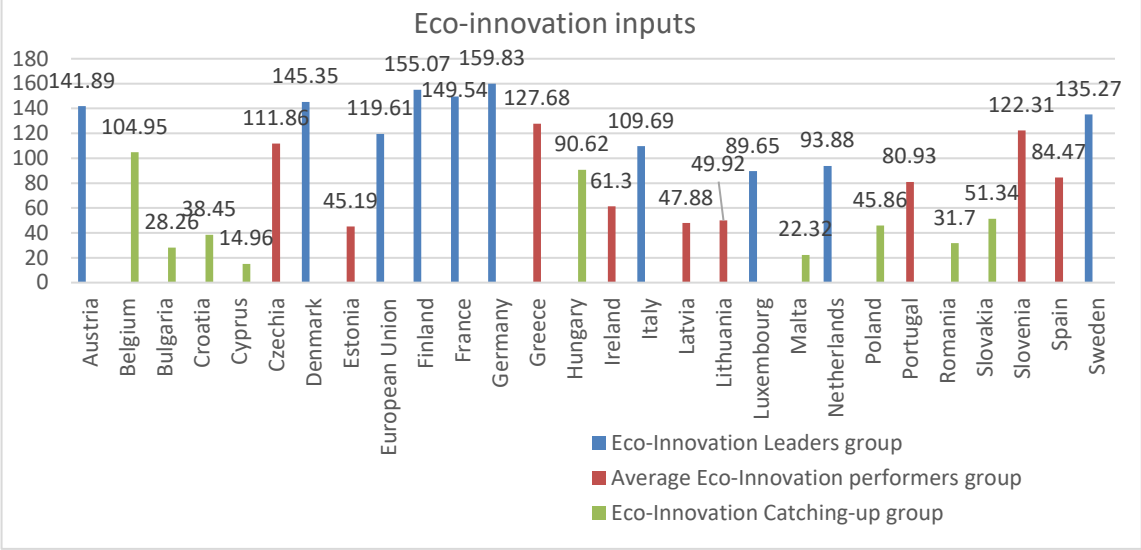


Figure 4. *Eco-Innovation Inputs in the EU countries*

Source: Derived from the author based on the European Eco-Innovation Scoreboard 2021-2022

Figure 4 shows the eco-innovation input values of EU Member States for 2021-2022 across three groups of countries: leaders, performers, and catching-up countries. In terms of eco-innovation inputs, all eco-innovation leaders perform admirably. Germany (159.83), Finland (155.07), France (149.54), and Denmark (145.35) have achieved especially good eco-innovation input scores. In the category of average EU performers, Greece, Slovenia, and the Czech Republic have achieved the highest scores according to the eco-innovation inputs. Cyprus (14.96) had the lowest score according to the eco-innovation inputs.

The eco-innovation activity scores of EU nations are shown in Figure 5. Estonia (243.26) and the Czech Republic (233.73) have achieved very impressive eco-innovation activity scores in the category of average EU performers (red line). In the category of eco-innovation leaders group (blue line), Finland (170.17) and Sweden (163.53) have achieved the highest scores according to eco-innovation activities. When it comes to eco-innovation activity scores, Poland, Malta, and

Belgium have the lowest relative scores among the nations that are catching up with eco-innovation, while the other nations in the group score reasonably well.

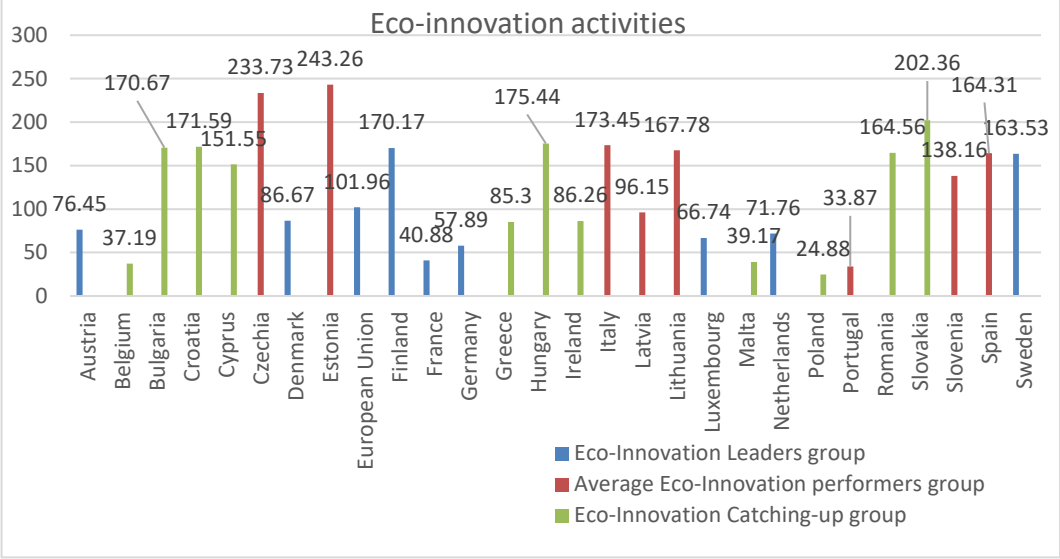


Figure 5. *Eco-Innovation activities in the EU countries*

Source: Derived from the author based on the European Eco-Innovation Scoreboard 2021-2022.

Interestingly, most of the EU countries that belong to the average eco-innovation performer's group and the eco-innovation catch-up group achieved higher scores than the leader group countries. Slovakia has achieved the best eco-innovation activity score in the category of eco-innovation catch-up group (green line). The eco-innovation activities score in Estonia (243.26), the best-scored EU country, was almost ten times higher than in Poland (the indicator score was 24.88), which scored the worst among the observed EU countries. The eco-innovation output scores of EU countries are shown in Figure 6.

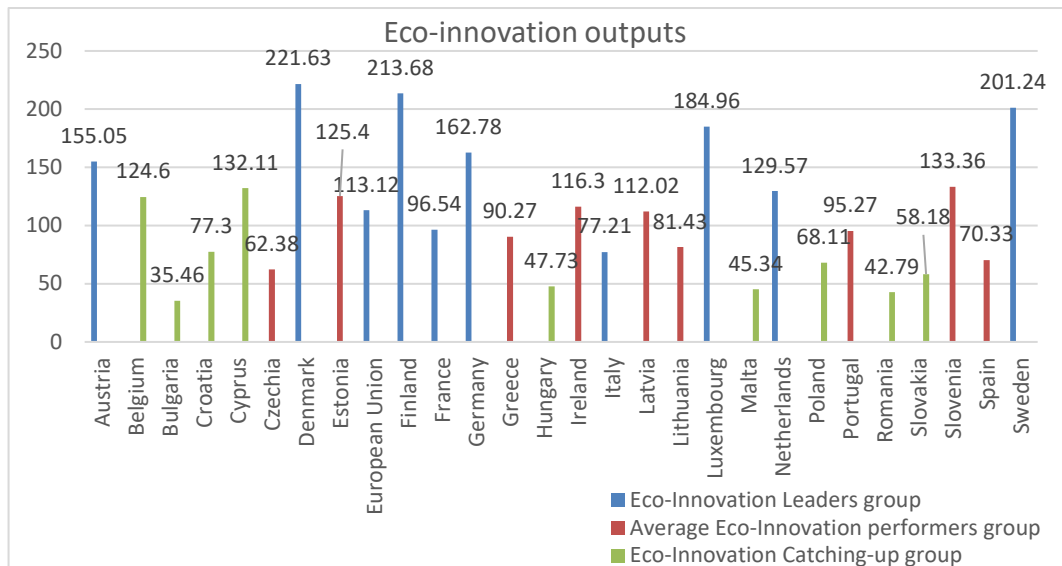


Figure 6. *Eco-Innovation outputs in the EU countries*

Source: Derived from the author based on the European Eco-Innovation Scoreboard 2021-2022.

As shown in Figure 6, Denmark (221.63) and Finland (213.68) have achieved the highest eco-innovation output scores in the category of the Eco-innovation Leaders group (blue line). Slovenia (133.36) has achieved the best eco-innovation output score in the category of average eco-innovation performers (red line). In the category of eco-innovation catch-up group, Cyprus (132.11) achieved the best score in eco-innovation outputs, and Bulgaria (35.46) had the lowest score. It is necessary to mention that the eco-innovation output score in Denmark, which was the best-scored EU country, was six times higher than in Bulgaria. Figure 7 presents resource-efficiency outcomes in the EU countries.

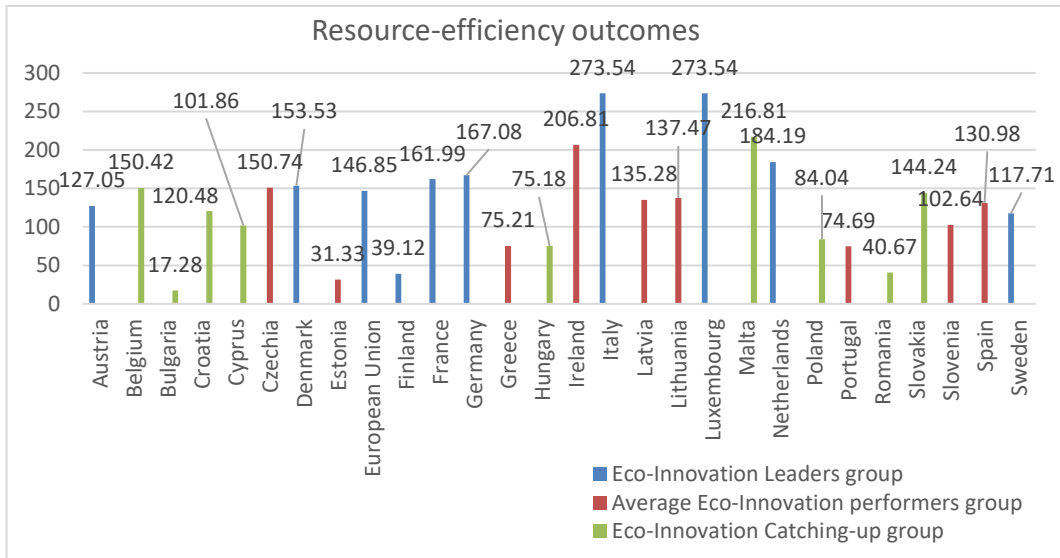


Figure 7. Resource-efficiency outcomes in the EU countries

Source: Derived from the author based on the European Eco-Innovation Scoreboard 2021-2022.

In the category of eco-innovation leaders group (blue line), Italy (273.54) and Luxembourg (273.54) have achieved the identical highest scores according to resource-efficiency outcomes. In the category of average eco-innovation performers (red line), Ireland (206.81) achieved the best result in terms of resource efficiency, and Estonia (31.33) was the worst-positioned country. When it comes to resource efficiency outcomes, Bulgaria (17.28) has the lowest score among all observed EU nations. Figure 8 presents socio-economic outcomes in the observed EU Member States.

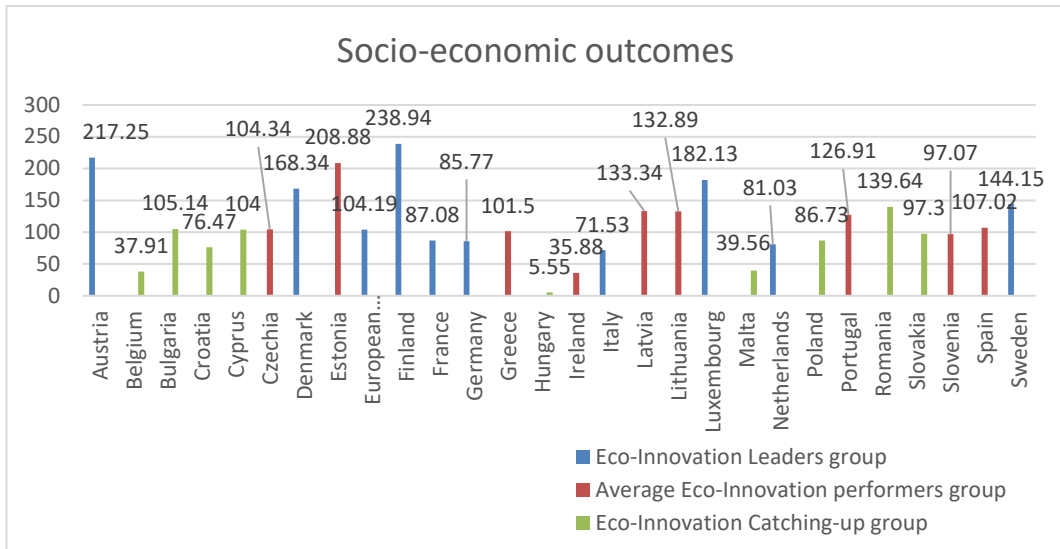


Figure 8. *Socio-economic outcomes in the EU countries*

Source: Derived from the author based on the European Eco-Innovation Scoreboard 2021-2022.

Finland (238.94) has achieved the highest socio-economic outcomes scores in the category of the Eco-Innovation Leaders group (blue line). Estonia (208.88) has achieved the best eco-socio-economic outputs score in the category of average eco-innovation performers (red line). In the category of the eco-innovation catch-up group, Romania (139.64) achieved the best score in socio-economic outcomes, and Hungary (5.55) had the lowest score of all EU countries. It can be noticed that the eco-innovation output score in Finland, which was the best-scored EU country, was forty-three times higher than in Hungary.

Eco-innovations have been incorporated into the effective sustainability initiatives and programs that Finland has developed. The government in Finland established several institutions to support environmental reforms in a variety of fields, such as consulting assistance for SMEs concentrating on the environmentally friendly economy, technological innovation, and sustainability. Environmental laws and adaptable economic policies in Finland encourage the use of eco-innovation and creative technology. In any scenario, it is imperative that the survey responses center on determining the reasons behind unequal or unfavorable levels of EU innovation in the member states, with an emphasis on

the elements that propel and strengthen national economies toward the creation and application of eco-innovations. Figure 9 breaks down the expected distribution of each policy component based on an overview of policy fields released by the European Commission. The percentage denotes the overall share of the plan marked for each EU policy component.

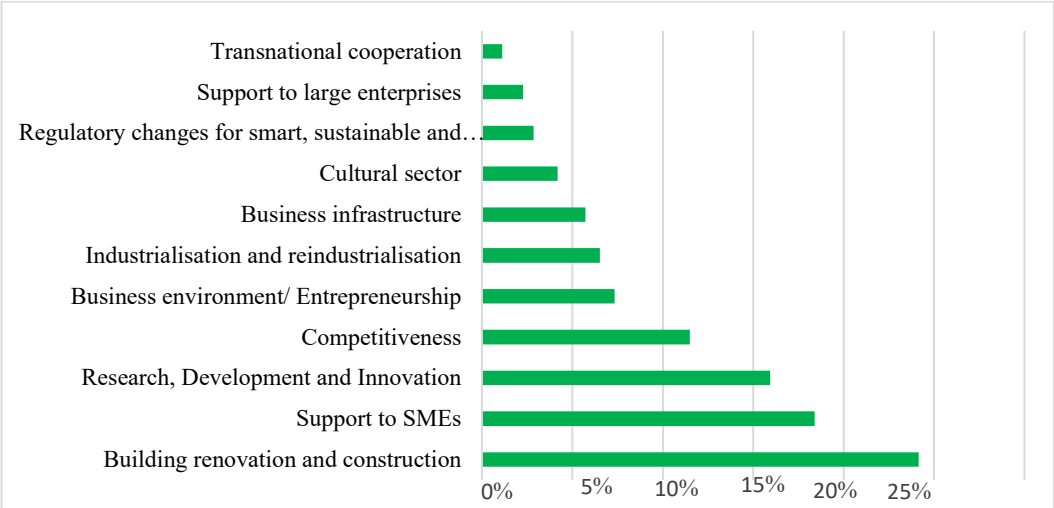


Figure 9. Summary of expenditures linked to smart, sustainable, and inclusive growth by policy field in the EU countries

Source: Derived by the author from the data published by the European Commission in 2022.

The substantial adjustments and expenditures that EU member states will carry out with EU funds will increase the competitiveness and resilience of their national economies and pave the path for a sustained recovery. The European Union (EU) backs policies that encourage entrepreneurial activity, competitiveness, smart, sustainable, and inclusive growth, industrialization and reindustrialization, infrastructure, better business environments, research, development, and innovation, and support small and medium-sized enterprises (SMEs). Determining the obstacles and facilitators of eco-innovation are crucial for any nation. The various categories of variables that fall under the categories of external, internal, and international influence how eco-innovation is implemented. The main obstacles to eco-innovation have been determined to be

the following: insufficient funding to support large enterprises, absence of adequate transnational cooperation, high regulatory charges for smart, sustainable, and inclusive growth, unclear market demand, unpredictable expenditures; inadequate business environment, ineffective legislation; and the absence of expertise and experience in Research and Development sector.

Conclusions

Eco-innovations are creative ways to accomplish sustainable growth and development and to obtain a competitive edge through environmentally friendly companies that maximize the use of currently available natural resources without endangering the well-being of the planet. The European Union has established high standards for mitigating the effects of environmental change. The Union wants to become carbon neutral by 2050 and cut its emissions of greenhouse gases by 55 percent by 2030. Policymakers, businesses, and stakeholders must all be committed to achieving these aims and be open to making adjustments. Europe needs to use eco-innovative practices to maintain its competitive edge in clean technology and to ensure that it is carbon neutral by 2050. Eco-innovative practices are defined as any invention that advances toward the objective of sustainable growth. And development. As a result, eco-innovation is essential to creating a circular economy, in which the foundation of production and consumption is the maximization of the product life cycle through material recycling and waste minimization. In addition to the factors that promote the development of eco-innovations, there are numerous obstacles associated with them that discourage EU economies from using these novel approaches.

The research results highlight the importance of improving eco-innovation in EU countries toward environmental responsibility and sustainability. It is crucial to compare national innovation accomplishments by using the eco-innovation index, which is constructed from suitable and objective indicators. This may serve as an essential part and a fundamental resource that provides

numerical numbers to comprehend the state of national eco-innovation in the EU countries. Sorting the index by subsections can provide helpful ramifications for decision-makers regarding the most effective way to support eco-innovation toward achieving sustainable growth and development. The eco-innovation indices are attractive because they provide EU member countries with country-specific values that indicate how competitive each nation is at the national level on newly raised environmental challenges.

Governments that are currently putting green measures into place may find that the performance of the analyzed economies can also provide helpful guidance for achieving sustainable development. With the right measure of the Eco-Innovation, the economies of the EU can also evaluate the overall welfare of the nations. The research suggests that sustainable policy implementation should be prioritized to boost prospective sustainable growth and development. It is expected that the creation and implementation of suitable, environmentally friendly policies will improve environmental conditions and contribute to the sustainable future of each European Union country.

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