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Quantifying the dynamics of relationships between eco-innovations and SDG 8

Ramon Arilla-Llorente [a], Beata Gavurova [b,*], Martin Rigelsky [c], Domingo Ribeiro-Soriano [d]

[a] ESIC University, Spain
[b] Technical University of Košice, Faculty of Mining, Ecology, Process Control and Geotechnologies, Letná 9, 042 00 Košice, Slovakia
[c] University of Prešov, Faculty of Management and Business, Prešov, Slovakia
[d] IUDESCOOP, University of Valencia, Spain

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ABSTRACT

Achieving the sustainable development goals is a major challenge for all the countries. The possibilities are constantly being sought to ensure environmental sustainability and economic sustainability at the same time. The optimal tool in this process is green finance, which is greatly important to achieve the sustainable development goals (SDGs) from the point of view of environmental and economic sustainability. The study's main goal was to analyze and quantify the relationships between the selected categories of eco-innovations and SDG 8 (Decent Work and Economic Growth) as one of the 17 Sustainable Development Goals established by the United Nations General Assembly in 2015. Annual data were collected from all the countries that have been European Union members since 2013. The outcomes of the regression models confirmed the assumption of a relationship between the eco-innovations and SDG 8. The closest relations were found in the field of employment, meaning that with the growth of eco-innovations, the employment rate should also increase. We also examine the countries' position in eco-innovations and SDG 8. Northern European countries received the most positive evaluations, while southern countries had negative evaluations. The study results provide valuable information to support the decision-making processes for the eco-innovation policymakers, as well as for the institutions and the regulatory authorities. Our findings clearly illustrate achieving SDG 8 through eco-innovative development and confirm the detailed insights into the explored relations between eco-innovations and human resources. This study's findings also support the creation of a national and international comparative platform and the development of benchmarking indicators in the eco-innovations and green growth field.

1. Introduction

In recent years, sustainable development and green financing have been topics in many countries.

There are several variants of the green finance definition, which the sustainability aspect is evident too from (Hafner et al., 2020). Green funds represent the financing of investments that provides environmental benefits in the field of air pollution, water, soil, as well as in the field of greenhouse gas emissions reduction, energy efficiency improvement, and adaptation to climate change. This issue requires strong legislation through its procedural demand as evidenced by the documents of the European Commission (2018, 2019, 2021a, 2021b). Green funds are considered a subset of sustainable finance (Berrou et al., 2019).

Numerous research teams have investigated the causal relations between green finance and sustainable development, while it is still unclear in which direction green finance should influence sustainable development. Furthermore, no empirical study has demonstrated the impact of green finance on achieving the 2030 Agenda goals.

Green finance is an elementary part of low-carbon green growth, as it links the financial processes with environmental improvement and economic growth. In recent years, green finance concepts have been developed, and the parameters of their appropriate adaptability for the conditions of different countries have been investigated (Soundarrajan and Vivek, 2016). Green finance is also related to the financing processes directly related to eco-innovations. The role of governments and

* Corresponding author.
E-mail addresses: ramon.arilla@esic.university (R. Arilla-Llorente), beata.gavurova@tuke.sk (B. Gavurova), martin.rigelsky@unipo.sk (M. Rigelsky), domingo.ribeiro@uv.es (D. Ribeiro-Soriano).

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international organizations should be to manage high-quality green investments and to prevent risks within the innovation ecosystem (Wang et al., 2022). The eco-innovation potential of the countries has a significant impact on achieving sustainable development goals (SDGs) (Saha et al., 2022).

Green finance can support the innovation of green technologies and the development of green microenterprises. These microenterprises can actively support the achievement of the SDGs through sustainable environment and economic sustainability. As a market-oriented investment or loan program, the Green Finance Program also considers the impact of risks and environmental stimuli in business decisions. It fully respects the natural capital and environmental value and aims to improve human well-being and social justice, achieving ecological integrity and environmental sustainability in the country. The mentioned aspects are closely related to SDGs, and the structure of its indicators is proof of an interconnection of the processes of sustainable, inclusive economic growth, eco-innovation, employment, and ensuring a decent life for the population.

The balance of the economic system strongly influences the financing mechanism of green projects, which initiates the solution to social imbalance problems that are very visible in the OECD countries. The social imbalances resulting from gender inequality can weaken the structural and institutional environment necessary to support eco-innovation.

Although many studies pay significant attention to this issue, the available research studies are highly fragmented or deal only with a partial part of the green finance issue without investigating causal relations and the impact effects. For this reason, many vital relations have not been analyzed and quantified so far, which would identify the main causes of the insufficient effects of the green finance mechanisms created to support eco-innovations.

These consistent facts motivated us to research, analyze, and quantify the relationships between the selected categories of eco-innovations and SDGs.

The research study is divided into several sections. The theoretical background section lists the research questions with the supporting scientific studies. The methodological section describes the techniques and approaches employed to examine the available data set. Furthermore, the data itself are characterized in this section. The analytical section is the subsequent chapter, involving all the analytical outcomes with their interpretation. The discussion and policy implications offer an overview of the comparison with the other studies related to the same or similar topic. The entire set of the obtained findings is summarized in the conclusion section.

2. Literature review

Green growth, eco-innovation, and economic globalization play a significant role in the ecological sustainability processes. Although many studies investigate the green growth issue, none have examined the individual explicit relations between eco-innovations and SDG 8, which focuses on “decent work and economic growth,” as one of the 17 Sustainable Development Goals established by the United Nations General Assembly in 2015. The pressures to create relevant, sustainable development policies require an examination of the causal relations between these variables and identifying the potential for the transformational and green finance processes.

Many studies indicate the necessity of a multidimensional investigation of this issue and the importance of sharing research knowledge to support the development of green finance as an elementary platform for sustainable and inclusive economic growth (Ahmad and Wu, 2022; Yao et al., 2022).

According to the fundamental structure of SDG 8 and its relationship to eco-innovations, we have to examine the relationships:

- between the eco-innovations and inclusive/sustainable economic growth,
- the eco-innovations, employment, and availability of appropriate jobs,
- and between the eco-innovations and green economy.

2.1. The relationship between eco-innovations and inclusive and sustainable economic growth

Costantini et al. (2023) explore innovation convergence among the countries from 2012 to 2021, identifying the three convergence groups in the overall Eco-innovation Index. They stated that gross domestic product (GDP) per capita and economic openness are the significant determinants. Research and development (R&D) investments, environmental taxation, and enterprise size were insignificant. The countries' economic growth brings environmental pollution, resource exhaustion, social injustice, and sustainability issues. Jo et al. (2015) and Chien (2023) evaluated the validity of the Eco-innovation Index developed to support the SDGs and investigated whether the eco-innovation factors adequately reflect sustainability.

Andabaka et al. (2019) evaluate the significant role of eco-innovations and analyze the impact of GDP growth, the quality of institutions, and recycling rates on the Eco-innovation Index in European Union (EU) countries. All these factors significantly and positively affected eco-innovations from 2010 to 2016. There are more and more frequent discussions about how eco-innovations affect the economic growth goals of the countries and improve the environment quality. According to Mačiulytė-Šniukienė and Sekhniashvili (2021), the development of ecological innovations influences the economic growth of the EU countries and positively affects environmental performance. Similar studies were also conducted on eco-innovations in nonEuropean countries. For example, Sun et al. (2021) examine the impact of eco-innovations and globalization in reducing CO_2 emissions in the United States. They find that GDP positively affects the CO_2 emissions level, while eco-innovation is a mitigating factor. Puertas and Marti (2021) investigated the determinants of greenhouse gases. Eco-innovations, CO_2 productivity, and environmental policies significantly impact emissions reduction.

Istrate et al. (2019) indicate geographical differences in eco-innovation use. Although the differences between central and eastern European countries have gradually decreased, several institutional, economic, and legislative barriers remain in eco-innovations. The aspect of globalization also influences this. Ahmad and Wu (2022) confirm that economic globalization has mixed effects. If the interaction with the eco-innovations is missing, it affects the processes of ecological deterioration because the involvement of the eco-innovations impacts the protection of the environment. Pakulska (2021) investigated the relationship between eco-innovations and economic growth. To a large extent, the hypothesis of a relatively high correlation between GDP and the eco-innovations was confirmed. Government spending on eco-innovations is usually more efficient than business spending because governments are more willing to bear the risk of investing in radical innovations than businesses. Qureshi et al. (2022) draw attention to the need for environmental monitoring between countries and adopting ecological innovation strategies to eliminate the CO_2 impacts. The authors found a significant negative association between the country-level Eco-innovation Index and the CO_2 produced by European firms for 2010–2018.

Hajdukiewicz and Pera (2023) justify linking the Eco-innovation Index to achieving the SDGs and drawing attention to innovation gaps between countries. They identify the most critical areas for improvement: the total number of workers and researchers in the R&D field, patents in the eco-innovations, energy productivity, and the introduction of sustainable products among small- and medium-sized enterprises.

The structural differences in R&D funding will significantly influence

the introduction of eco-innovations (Jesic et al., 2021). The European countries are characterized by technological and institutional heterogeneity, although the EU countries are subject to the same legislative directives. Chatzistamoulou and Koundouri (2020) revealed the heterogeneous patterns of the Eco-innovation Index and the global competitiveness index of the EU countries. The Southern European countries perform better in almost all the aspects of the indices. They consider creating policies aimed at the specific clusters of the countries to be the optimal strategy. To create effective eco-innovation strategies, it will be important to systematically develop the eco-innovation indices to create a comparative base and reveal innovation potential and barriers. This approach will allow us to implement new determinants into the composite indicators of the eco-innovations.

Su et al. (2021) confirmed in their study that fiscal decentralization and eco-innovations promote renewable energy consumption and lower nonrenewable energy consumption. An improvement in the political risk index and an increase in renewable energy R&D increase the consumption of renewable energy and decrease the consumption of nonrenewable energy.

Several factors can influence the effectiveness of the policies supporting ecological innovation. Ahsan et al. (2023) confirm that larger and more profitable European enterprises with low debt levels reach environmental results. The authors pointed out that the eco-innovation policies at the level of European countries restrict the environmental efforts of enterprises operating in sensitive industries. Ma et al. (2022) also draw attention to the impact of financial inclusion and exports on reducing emissions and the impact of GDP and imports causing trade-adjusted emissions on reducing emissions. In addition to financial inclusion, there is a two-way relationship between all the variables. Most research studies focus on the reactive eco-innovation approaches. Johl and Toha (2021) justify the effects of proactive eco-innovations (product eco-innovations, process, and technological eco-innovations) and their impact on the financial performance of enterprises and the circular economy processes.

According to these studies, the following research questions were formulated:

RQ1: Does GDP represent a significant relation between the Eco-innovation Index and economic development?

RQ2: Is there a significant relation between the Eco-innovation Index and investments in the selected fields?

2.2. The relationship between eco-innovation, productive employment, and decent work for all

Some authors have investigated the relationships between eco-innovations and employment. Increased labor productivity and eco-innovations also influence the introduction of new work forms and programs (Bucea-Manea-Ţoniş et al., 2021). Smart working is also related to eco-innovations, ecological products, processes, and green organizational procedures. The ecological ecosystems simultaneously transform the strategic leaders, who are more innovative, flexible, and adaptable to transformational changes (Macke and Genari, 2019; Balconi et al., 2019). Larbi-Siaw et al. (2022) investigate the importance of eco-innovations in achieving the enterprises' performance sustainability and, thus, draw attention to the sequence of the processes. In the first phase, it is possible to improve the environmental performance of enterprises by implementing processes, then improve social performance via investing in R&D, new ecological management procedures, and staff sensitization on the eco-innovations. Although many research studies have investigated the relationship between eco-innovations and employment (Passaro et al., 2023), few studies examine this issue at the level of the industries and enterprises (Francesco et al., 2018; Orlando et al., 2020). The reason lies in the data limitations. The available empirical evidence is also unclear. According to Horbach et al. (2012), product eco-innovations do not stimulate employment growth, but process eco-innovations positively affect employment. Gagliardi et al. (2016) confirm that the green innovations measured by environmental patents impact long-term employment growth for manufacturing firms.

Kunapatarawong and Martínez-Ros (2016) compare enterprises with the policy-driven eco-innovations to enterprises that implement the voluntary eco-innovations. They demonstrated a positive relationship between voluntary eco-innovations and employment but found no relationship between employment and policy-driven eco-innovations.

The adoption of eco-innovations by employees is also influenced by educational activities and training (Bossle et al., 2016). According to Kesidou and Demirel (2012), increased investments in eco-innovations should be stimulated by cost savings, the organizational capabilities of enterprises, and stricter environmental regulations. To a lesser extent, the stimulation of the eco-innovations should be based on alteration in the customer demand requirements. The sectoral point of view is also essential. Mac Lennan et al. (2023) indicate that the process-based eco-innovations of the technological trends prevailing in the fashion industry and eco-innovations in product development follow. Arranz et al. (2019) also investigated the regional aspects of the eco-innovations. The authors evaluated the density of the regional enterprises, regional income per capita, and financing mechanisms for eco-innovations as the most important aspects for developing eco-innovations in enterprises.

Muszyński et al. (2011), applying an instance of forestry, point to the relation of eco-innovations with specific work in a very diverse work environment, which increases work risk. The introduction of innovative processes should be linked with the results of science and technology and with activities preventing accidents and work accidents. Araújo et al. (2018) point to this issue from the perspective of the construction sector, which concentrates 25% to 40% of the world's energy and uses 30% to 40% of greenhouse gases. Although the rate of work accidents has decreased significantly in recent years, it is still among the highest within the sectors. Green building is also often mentioned as risky (Haslam et al., 2005) because content in green jobs is less routine than in nongreen jobs, creating room for additional risks (Vona et al., 2018). Some risks in the construction sector are new and related to new materials and technologies used in green projects. >50% of work accidents are reported in the construction industry. Santos et al. (2015) investigated the issue of the eco-innovation performance in a sugar and ethanol production company. In the social construct, there were improvements in absenteeism and turnover; however, the number of work accidents increased significantly. The elimination of work accidents when adopting eco-innovations will require systematic analyses of the level of adoption of sustainable eco-innovations implemented in the processes of industrial enterprises (Sehnem et al., 2016; Peyravi et al., 2023). Rathnayake and Karunasena (2016) confirm that up to 80% of occupational accidents are caused by employee behavior. They recommend forming strategies to improve safety and health protection at work in all sectors and paying significant attention to the ethical climate in companies. Divella and Sterlacchini (2021) conducted a microeconometric analysis of factors that facilitate the introduction of sustainable and responsible innovations in enterprises. Enterprises increasingly look at the health and safety of their employees as an innovation goal.

The results of the studies above allowed us to formulate the following research questions:

RQ3: Is there a significant relationship between the Eco-innovation Index and employment?

RQ4: Is there a significant relationship between the Eco-innovation Index and fatal work accidents?

RQ5: Is there a significant relationship between the Eco-innovation Index and the risk-of-poverty employees?

RQ6: Is there a significant relationship between the Eco-innovation Index and unemployment due to nurse duties?

2.3. The eco-innovations and green economy

The circular economy (CE) concept has been intensively developed for several years; however, regional policy has not yet established

appropriate indicators for measuring eco-innovations. Because of regulatory pressures, manufacturers have been increasingly investing in green technologies to reduce emissions and to collect products after their life use as recycled raw materials. Many strategies have been tested to evaluate which should lead to collecting raw materials (producer, seller, or third party) regarding economic benefits, social welfare, and environmental benefits (Zhang et al., 2021). The processes of the eco-innovations and CE are interconnected, so it is essential to compare the transition levels to CE, including the eco-innovations (Ferasso et al., 2020; Smol et al., 2017).

Ahmad et al. (2021) define the assumptions that eco-innovations will facilitate sustainable urbanization in the G7 countries. Greater financial integration of the G7 countries will support better financing of eco-innovation projects, promote sustainable urbanization, and accelerate economic growth through sustainable transformation processes. Environmental regulations, green patents, ecological taxes, and others may be appropriate instruments to support eco-innovative development. Mahmood et al. (2022) justify the importance of eco-taxes in supporting ecological innovations with economic benefits and sustainability between individuals and societies. The negative impact of eco-innovations may also depend on the ideology of political leadership and environmental sensitivity (Zaman et al., 2021). In their study, Lasisi et al. (2022) emphasize the importance of evaluating the cost-effectiveness and energy efficiency of technology-related economic inputs, especially during the design and production process. The author confirms that oil and environmental technologies support economic growth in the countries, but environmental innovations restrict energy-economic output. Linking energy transformation with eco-innovations and environmental sustainability is recommended by Zhang (2023).

Industrialization positively and significantly affects CO_2. Likewise, technology export and R&D are positively associated with CO_2 emissions. Cost savings are a significant motivation for reducing the consumption of energy and materials, while the role of energy prices, raw materials, and taxes is also important (Horbach et al., 2012). Platon et al. (2023) confirm that eco-innovations and recycling have a significant impact on reducing the material footprint per inhabitant. They consider the material footprint per inhabitant to be a suitable indicator of material consumption caused by economic and social activities. Gervais et al. (2021) point to increasing problems with the availability of raw materials in rapidly developing sectors. According to the authors, new concepts of solar cells require the complementary creation of effective strategies aimed at the sustainable use of materials. This problem is also perceived by Mauler et al. (2022), who integrate expectations of future material prices and cost reductions influenced by technological innovation in their study. One of the solutions is the creation of European innovation partnerships for raw materials on new solutions for sustainable production of raw materials (Malehmir et al., 2019; Platon et al., 2023). Martins and Castro (2020) point to the EU's critical raw materials regarding global stocks and the instability of prices, markets, and the risks of supply interruptions.

In the context of the mentioned research studies, the research question was formulated:

RQ7: Is there a significant relation between the Eco-innovation Index and the consumption of input raw materials?

3. Methodology

The aim of the study is to analyze and to quantify the relationships between the eco-innovations and SDG 8 in EU countries. Based on the reviewed research studies, the seven research questions were formulated:

RQ1: Is there a significant relationship between the Eco-innovation Index and economic development?

RQ2: Is there a significant relationship between the Eco-innovation Index and investments in the selected fields?

RQ3: Is there a significant relationship between the Eco-innovation Index and employment?

RQ4: Is there a significant relationship between the Eco-innovation Index and fatal work accidents?

RQ5: Is there a significant relationship between the Eco-innovation Index and the risk-of-poverty employees?

RQ6: Is there a significant relationship between the Eco-innovation Index and unemployment due to nurse duties?

RQ7: Is there a significant relationship between the Eco-innovation Index and the consumption of input raw materials?

The secondary data are explored to achieve the outcomes related to the particular research questions. Data from the EU databases since 2013 were acquired from the Eco-innovation Index (European Commission, 2023) and SDGs (Eurostat, 2023). The beginning of the period is selected according to the availability of the Eco-innovation Index indicator in the Eurostat database. The analytical processes examined data on an annual basis for all the EU countries ($n = 27$): Austria (AT), Belgium (BE), Bulgaria (BG), Croatia (HR), Cyprus (CY), Czechia (CZ), Denmark (DK), Estonia (EE), Finland (FI), France (FR), Germany (DE), Greece (EL), Hungary (HU), Ireland (IE), Italy (IT), Latvia (LV), Lithuania (LT), Luxembourg (LU), Malta (MT), Netherlands (NL), Poland (PL), Portugal (PT), Romania (RO), Slovakia (SK), Slovenia (SI), Spain (ES), and Sweden (SE).

Table 1 contains a description of all the explored variables. The 12 dependent variables were applied in the regression analysis (GDP euro, GDP change, Bus inv., Gov inv., House inv., Young empl M, Young empl F, Empl M, Empl F, Long Unempl M, Long Unempl F, Fatal acc M, Fatal acc F, Work risk of poverty, Caring M, Caring F) and one independent variable (EII). The following table describes the structure of the data set. The abbreviations of the variables, along with their measurement evaluation, are shown below.

As we worked with the data from the EU statistical office, the statistical processes were selected according to their suitability. Therefore, the panel regression models are selected to assess the relationships, meaning the models can capture the structure of the countries. The spatial models were also explored, as there is a justified assumption of the existence of spatial dependence. The results declaring the countries' positions were visualized through cluster analysis techniques, considering the specifics of the selected countries.

A descriptive statistical analysis was conducted in the first step of the analytical process. Subsequently, a simple panel regression analysis was performed. The fixed and random effects models were applied. The decision-making process for selecting the most appropriate model depended on the results of the F test for the individual effects, while this test assessed the countries' structure. Subsequently, the Hausman test was applied to support the decision on the suitability of the fixed (White) or random effects model. Through the Breusch–Pagan Test, most of the models were evaluated as heteroscedastic. According to this output, robust estimates were explored. The Arellano estimator was employed for the fixed effect models, and the White 2 estimator was employed for the random effects. The reliability of the individual models was assessed by applying a robustness test according to the change in the structure (selection of the countries). After applying the regression analysis, the data were aggregated and standardized, and the adjusted aggregated data ($n = 27$) were explored. A regression analysis was applied to this data applying several models (OLS: ordinary least squares, SLX: spatially lagged X, SAR: spatial lag autoregressive model, and SEM: spatial error model). As there were few statistical units, the condition of normality (Shapiro–Wilk normality test) and the constant variability of the residuals were verified through the Breusch–Pagan test. To evaluate the conditions of the spatial models, we applied tests for evaluating spatial dependence (Moran I, Lagrange multiplier diagnostics for spatial dependence, and the spatial Hausman test). The final section focused on evaluating the position of the countries themselves. A cluster analysis (partitioning around medoids via the Manhattan distance) was applied to the aggregated data. The appropriate number of clusters was estimated through the silhouette method.

Table 1
Description of variables.

Abbreviation	Variable	Measurement	Time end
GDP euro	Real GDP per capita	Chain linked volumes 2010 euro per capita	2022
GDP change	Real GDP per capita	Chain linked volumes, percentage change on the previous period, per capita	2021
Bus inv	Investment share of GDP Business investment	Percentage	2022
Gov inv	Investment share of GDP Government investment Percentage	Percentage	2022
House inv	Investment share of GDP Households investment Percentage	Percentage	2022
Young empl M	Young people neither in employment nor in education and training From 15 to 29 years Males	Percentage of total population	2022
Young empl F	Young people neither in employment nor in education and training From 15 to 29 years Females	Percentage of total population	2022
Empl M	Employment rate From 20 to 64 years Males	Percentage of total population	2022
Empl F	Employment rate From 20 to 64 years Females	Percentage of total population	2022
Long Unempl M	Long-term unemployment rate From 15 to 74 years Males	Percentage of population in the labor force	2022
Long Unempl F	Long-term unemployment rate From 15 to 74 years Females	Percentage of population in the labor force	2022
Fatal acc M	Fatal accidents at work Males	per 100,000 workers	2021
Fatal acc F	Fatal accidents at work Females	per 100,000 workers	2021
Work risk of poverty	In work at-risk-of-poverty rate Employed persons 18 years or over Percentage	Percentage of employed persons 18 years or over	2022
Caring M	Persons outside the labor force due to caring responsibilities Care of adults with disabilities or children and other family or personal reasons From 20 to 64 years Males	Percentage of total population	2022
Caring F	Persons outside the labor force due to caring responsibilities Care of adults with disabilities or children and other family or personal reasons From 20 to 64 years Females	Percentage of total population	2022
RMC	Raw material consumption	Tons per capita	2020
EII	Eco-innovation Index	Index (100-European Union)	2022

4. Results

The outcomes of the analytical processes linked to the research questions are presented in this study section.

In addition to the standard statistical characteristics, Table 2 also offers information on the occurrence of missing data (first row). The data from the 27 countries with an annual interval from 2013 to 2022 (270 observations) were explored. The most missing observations were recorded for the indicators Caring_M ($n = 60$, 22.2%) and RMC ($n = 54$, 20.0%). The missing values were also recorded for the other indicators, where the percentage occurrence of these values was above 10%. The missing values for the specific countries indicate that Malta appears to be the most problematic country that does not show a single observation in the Bus_inv, House_inv, and Caring_M indicators.

For a more comprehensive understanding of the data, evaluating the outcomes of the descriptive analysis themselves is appropriate. Several indicators are in the groups (for instance, men and women); hence, evaluating the differences within the group is appropriate. From the technical point of view of the subsequently applied analyses, it is appropriate to point out the characteristics of the position of the Bus inv. indicator (kurt = 25.14), which indicates a specific deformation of the normal distribution. The highest data variability occurred for the GDP_change indicator (CV = 1.81), which seems logical, as it is a naturally highly variable indicator.

The following section aims to evaluate the relationships between the Eco-innovation Index and the individual indicators of SDG 8.

Before applying panel regression models, we focused on the application conditions of the models (Table 3). The first column contains the output of the test, which assessed the importance of considering the structure of countries. In all but one case (GDP change: statistic = 1.5333, p-value = 0.0537), significance was confirmed at an α level lower than 0.05. The Hausman test helped to decide on the preferences of the random or fixed (within) effect model. The results of the Breusch–Pagan test indicated that significant heteroscedasticity occurs in most cases. The models were estimated through robust estimators (White for random effect models and Arellano for within models).

Table 4 demonstrates the results of the individual models. The research question RQ1 investigated the relationship between eco-innovation and GDP. Both GDP per capita and year-on-year change express a statistically significant relation. A positive relationship was identified for GDP per capita, which can be seen as clearly positive. In contrast, a negative relationship was identified with the annual change in GDP, indicating that lower values of the annual GDP change are associated with higher values of the Eco-innovation Index. The research question RQ2 focused on the investments of the business, government, and household sectors. Only the household sector appears significant at the 5% significance level ($\beta = 0.024$, p-value <0.001).

The research question RQ3 related to employment can be answered positively. Eco-innovations positively and significantly impact employment, as proven in several models. Within RQ4, the relationship between eco-innovations and the incidence of fatal accidents cannot be directly confirmed. The relationship appears significant for men ($\beta = -0.018$, p-value = 0.016) but not for women ($\beta = -0.004$, p-value = 0.084). In both cases, the negative direction of the relationship was demonstrated, which can be perceived positively.

The research question RQ5 was focused on linking the Eco-innovation Index with the risk of poverty among employees. The results show a negative relationship ($\beta = -0.013$, p-value = 0.026), which can be perceived positively. With an increase in eco-innovations, it is possible to expect a reduction in the risk of poverty among those employed. A significant relation between the eco-innovations and the ratio of unemployed due to nursing (RQ6) was found among women ($\beta = -0.011$, p-value = 0.001). The research question RQ7 was focused on raw material consumption. The relationship between the eco-innovations and RMC is insignificant; therefore, this research question cannot be answered positively.

Some regression models present a relatively low coefficient of determination even if the condition of a statistically significant relationship is met. These are the GDP change Fatal acc M models. On the one hand, it is appropriate to emphasize that our focus was on the simple regression models to capture the purest possible relationships on a broader range of the investigated variables. The outcomes declaring different intensities of relationships help design future research questions and assumptions more effectively. The results indicate that the field of employment can play a relatively important role in explaining changes in eco-innovations.

The additional results were obtained to evaluate the closeness of the relationships. The closest relationships were found in employment, and eco-innovations have the closest connection to employment or

Table 2
Outcome of the descriptive analysis.

Variable	Missing	Mean	Median	Standard deviation	Coefficient of variation	Min	Max	Kurt	Skew
GDP euro	0	26,548.00	20,945.00	17,232.02	0.65	5390.00	84,750.00	2.57	1.52
GDP change	27	2.16	2.20	3.91	1.81	−11.80	23.30	4.99	0.15
Bus inv	32	13.16	12.76	4.48	0.34	4.52	50.44	25.14	3.62
Gov inv	23	3.58	3.49	1.08	0.30	1.54	6.64	−0.24	0.45
House inv	32	4.52	4.45	1.50	0.33	0.76	9.25	0.19	0.24
Young empl M	0	11.60	10.50	4.87	0.42	3.60	27.70	0.28	0.92
Young empl F	0	14.58	13.65	5.67	0.39	4.20	30.60	0.03	0.74
Empl M	0	76.97	77.50	5.53	0.07	61.60	88.60	−0.27	−0.34
Empl F	0	67.03	68.90	8.02	0.12	42.90	80.40	0.07	−0.82
Long Unempl M	0	3.58	2.60	2.75	0.77	0.50	15.00	2.91	1.71
Long Unempl F	0	3.60	2.25	3.59	1.00	0.50	20.80	7.21	2.54
Fatal acc M	29	3.95	3.66	2.07	0.52	0.55	11.17	0.88	0.89
Fatal acc F	29	0.23	0.17	0.22	0.96	0.00	1.45	3.51	1.51
Work risk of poverty	0	8.14	7.80	3.17	0.39	2.50	19.80	0.95	0.79
Caring M	60	0.34	0.30	0.23	0.69	0.00	1.10	1.55	1.41
Caring F	3	1.55	1.30	1.06	0.69	0.10	4.40	0.32	1.01
RMC	54	18.00	16.02	7.70	0.43	7.34	52.53	4.49	1.84
EII	0	103.00	98.30	35.39	0.34	25.18	181.55	−0.32	0.49

Note: Source: Eurostat (2023).

Table 3
Conditions for an application of the panel regression analysis.

Variable	F test Statistic (p val)	Hausman test Statistic (p val)	Breusch–Pagan test Statistic (p val)	Model
GDP euro	237.78 (<0.001)	13.849 (<0.001)	46.031 (<0.001)	PLM Fixed A
GDP change	1.5333 (0.0537)	3.0772 (0.0794)	4.9703 (0.0258)	PLM Random W
Bus inv	24.205 (<0.001)	7.109 (0.0077)	3.0709 (0.0797)	PLM Fixed
Gov inv	22.921 (<0.001)	3.351 (0.0572)	11.666 (<0.001)	PLM Random W
House inv	42.507 (<0.001)	2.7423 (0.0977)	0.9679 (0.3252)	PLM Random
Young empl M	47.514 (<0.001)	12.453 (<0.001)	8.6074 (0.0033)	PLM Fixed A
Young empl F	87.56 (<0.001)	7.2268 (0.0072)	2.6979 (0.1005)	PLM Fixed
Empl M	43.18 (<0.001)	86.75 (<0.001)	9.8512 (0.0017)	PLM Fixed A
Empl F	97.819 (<0.001)	51.976 (<0.001)	4.8243 (0.0281)	PLM Fixed A
Long Unempl M	26.749 (<0.001)	78.085 (<0.001)	42.256 (<0.001)	PLM Fixed A
Long Unempl F	61.004 (<0.001)	31.628 (<0.001)	51.992 (<0.001)	PLM Fixed A
Fatal acc M	20.909 (<0.001)	0.1142 (0.7353)	0.4186 (0.5176)	PLM Random
Fatal acc F	3.9467 (<0.001)	7.3988 (0.0065)	10.486 (0.0012)	PLM Fixed A
Work risk of poverty	138.95 (<0.001)	0.0010 (0.9748)	0.0477 (0.8271)	PLM Random
Caring M	16.119 (<0.001)	6.7306 (0.0095)	20.518 (<0.001)	PLM Fixed A
Caring F	34.853 (<0.001)	0.9067 (0.341)	11.055 (<0.001)	PLM Random W
RMC	105.84 (<0.001)	8.4637 (0.004)	32.741 (<0.001)	PLM Fixed A

Note: A–Arellano estimator; W–White estimator.

Table 4
Outcomes of panel regression analysis.

Dependent variable	Observations	EII	Intercept	R2/R2 adj
		β [st.error] p val	α [st.error] p val	
GDP euro	270	**161.164 [57.520] 0.005**	–	0.254/ 0.170
GDP change	243	**−0.021 [0.007] 0.002**	4.301 [0.819] <0.001	0.027/ 0.023
Bus inv	238	0.085 [0.046] 0.065	–	0.066/ −0.049
Gov inv	247	0.005 [0.004] 0.190	3.043 [0.553] <0.001	0.025/ 0.021
House inv	238	**0.024 [0.005] < 0.001**	1.946 [0.612] 0.002	0.101/ 0.098
Young empl M	270	**−0.141 [0.029] < 0.001**	–	0.303/ 0.225
Young empl F	270	**−0.158 [0.022] < 0.001**	–	0.455/ 0.394
Empl M	270	**0.253 [0.029] < 0.001**	–	0.475/ 0.416
Empl F	270	**0.297 [0.026] < 0.001**	–	0.571/ 0.524
Long Unempl M	270	**−0.137 [0.020] < 0.001**	–	0.438/ 0.375
Long Unempl F	270	**−0.122 [0.020] < 0.001**	–	0.405/ 0.339
Fatal acc M	241	**−0.018 [0.007] 0.016**	5.766 [0.817] <0.001	0.026/ 0.022
Fatal acc F	241	−0.004 [0.003] 0.084	–	0.031/ −0.092
Work risk of poverty	270	**−0.013 [0.006] 0.026**	9.473 [0.893] <0.001	0.019/ −0.091
Caring M	210	0.002 [0.002] 0.230	–	0.024/ −0.114
Caring F	267	**−0.011 [0.003] 0.001**	2.692 [0.423] <0.001	0.049/ 0.046
RMC	216	0.017 [0.027] 0.538	–	0.005/ −0.138

decreasing unemployment.

We also focused on a critical statistical view of the presented results. For this reason, a robustness test was applied by altering the sample set (via sample function in R that randomly generates these countries), whose results are demonstrated in Tables 5 Table 6. Eighteen countries were randomly selected (Table 5: NL, SE, FR, CY, MT, HR, EE, CZ, BE, PL, LU, LT, FI, AT, EL, SK, SI, and ES; Table 6: CY, DK, DE, CZ, IE, LU, FI, EE, ES, SE, HR, LV, PL, FR, BE, SK, PT, and HU). The robustness evaluation compared the results from Tables 5 and 6 with those from Table 4. It is clear from the comparison that there were no significant changes, especially in the coefficients' signs. A change in significance is presented in some cases, but these are rare cases in the models in Table 4 that move at a level close to 5%. Therefore, we perceive the evaluation of the mentioned test as positive, and, in particular, we perceive the

Table 5
Outcomes of the panel regression analysis – robustness test 1.

Dependent variable	Observations	EII	Intercept	R2/R2 adj
		β [st.error] p val	α [st.error] p val	
GDP euro	180	**110.491 [16.305] < 0.001**	–	0.479/ 0.421
GDP change	162	**−0.021 [0.007] 0.003**	3.984 [0.878] <0.001	0.040/ 0.034
Bus inv	158	**0.032 [0.014] 0.021**	–	0.059/ −0.055
Gov inv	167	0.006 [0.003] 0.112	3.113 [0.455] <0.001	0.008/ 0.002
House inv	158	**0.026 [0.006] < 0.001**	1.872 [0.783] 0.018	0.123/ 0.118
Young empl M	180	**−0.132 [0.036] < 0.001**	–	0.292/ 0.212
Young empl F	180	**−0.141 [0.028] < 0.001**	–	0.415/ 0.350
Empl M	180	**0.246 [0.035] < 0.001**	–	0.526/ 0.473
Empl F	180	**0.309 [0.033] < 0.001**	–	0.614/ 0.571
Long Unempl M	180	**−0.130 [0.025] < 0.001**	–	0.397/ 0.330
Long Unempl F	180	**−0.125 [0.028] < 0.001**	–	0.377/ 0.308
Fatal acc M	161	−0.010 [0.009] 0.298	4.618 [1.005] <0.001	0.007/ 0.001
Fatal acc F	161	−0.005 [0.004] 0.180	–	0.031/ −0.092
Work risk of poverty	180	**−0.021 [0.007] 0.002**	9.724 [1.005] <0.001	0.074/ −0.030
Caring M	138	0.000 [0.002] 0.850	–	0.001/ −0.141
Caring F	178	**−0.021 [0.004] < 0.001**	3.730 [0.520] <0.001	0.170/ 0.165
RMC	144	0.010 [0.033] 0.775	–	0.002/ −0.142

Table 6
Outcomes of the panel regression analysis – robustness test 2.

Dependent variable	Observations	EII	Intercept	R2/R2 adj
		β [st.error] p val	α [st.error] p val	
GDP euro	180	**234.907 [102.345] 0.023**	–	0.479/ 0.421
GDP change	162	**−0.021 [0.008] 0.014**	4.393 [1.123] <0.001	0.040/ 0.034
Bus inv	169	0.097 [0.072] 0.176	–	0.059/ −0.055
Gov inv	169	**0.012 [0.005] 0.014**	2.359 [0.669] <0.001	0.008/ 0.002
House inv	169	**0.025 [0.006] < 0.001**	1.820 [0.793] 0.023	0.123/ 0.118
Young empl M	180	**−0.160 [0.039] < 0.001**	–	0.292/ 0.212
Young empl F	180	**−0.164 [0.027] < 0.001**	–	0.415/ 0.350
Empl M	180	**0.289 [0.044] < 0.001**	–	0.526/ 0.473
Empl F	180	**0.318 [0.034] < 0.001**	–	0.614/ 0.571
Long Unempl M	180	**−0.160 [0.029] < 0.001**	–	0.397/ 0.330
Long Unempl F	180	**−0.141 [0.027] < 0.001**	–	0.377/ 0.308
Fatal acc M	161	−0.015 [0.008] 0.083	5.219 [0.907] <0.001	0.007/ 0.001
Fatal acc F	161	−0.007 [0.004] 0.060	–	0.031/ −0.092
Work risk of poverty	180	**−0.015 [0.007] 0.025**	9.218 [0.996] <0.001	0.074/ −0.030
Caring M	143	0.001 [0.003] 0.771	–	0.001/ −0.141
Caring F	178	**−0.016 [0.004] < 0.001**	3.293 [0.538] <0.001	0.170/ 0.165
RMC	144	0.044 [0.037] 0.233	–	0.002/ −0.142

relationships with employment to be sufficiently stable.

The subsequent analytical processes investigated the relationship between the overall output of SDG 8 and the Eco-innovation Index. For this reason, in the first step, the average values of the indicators in the individual countries were calculated (the average was calculated for the individual years), and the data were standardized from 0 to 1, where 0 means a negative assessment, and 1 is a positive assessment. A higher value represents a more favorable result for the GDP, GDP change, Bus inv., Gov inv., House inv., Empl M, Empl F, RMC, and EII indicators. For instance, after standardization, the lowest level reaches 0, and the highest level reaches 1. Conversely, the higher value indicators Young empl M, Young empl F, Long Unempl M, Long Unempl F, Fatal acc M, Fatal acc F, Work risk of poverty, Caring M, Caring F represents a negative assessment–for instance, the highest value after standardization is expressed as 0, and the lowest value is expressed by 1. The standardized SDG 8 indicators were averaged, and the aggregate variable SDG 8 Evaluation (Eval SDG 8) was created through this process. The standardized Eco-innovation Index variable was named the Eco-innovation Index Evaluation (Eval EII).

Fig. 1 shows the evaluation of the selected indicators. Green highlighting represents a positive output, and on the contrary, red highlighting represents a negative output. For both indicators, the southern countries acquire a more negative evaluation than those in Northern Europe. Regarding these outputs, it is possible to assume a specific spatial dependence.

The following sections focused on applying regression models, where the independent variable is the Eco-innovation Index Evaluation indicator and the dependent SDG 8 Evaluation.

Table 7 shows the outcomes of the regression models of the relationship between SDG 8 Evaluation and Eco-innovation Index Evaluation. In the first steps, the application conditions of the mentioned models were evaluated. The normality condition was met, and no significant heteroscedasticity was found in the OLS model. The spatial matrix was created by applying the K nearest neighbors for spatial weights, while the relationships among the countries were analyzed through linkage with the five nearest neighboring countries ($k = 5$). Moran's test for spatial dependence did not show significant spatial dependence, which is similar to the other tests specific to the spatial regression models. The results show a significant relationship between the Eco-innovation Index Evaluation and SDG 8 Evaluation in the models. All the models represent a positive relationship; thus, with the growth of the SDG 8 Evaluation, an increase in the Eco-innovation Index can also be expected. The coefficients of determination do not reach high values, but a demonstrable relationship is evident. The lower value could be explained because these are simple regression models.

The last analytical process was applied to evaluate the countries'

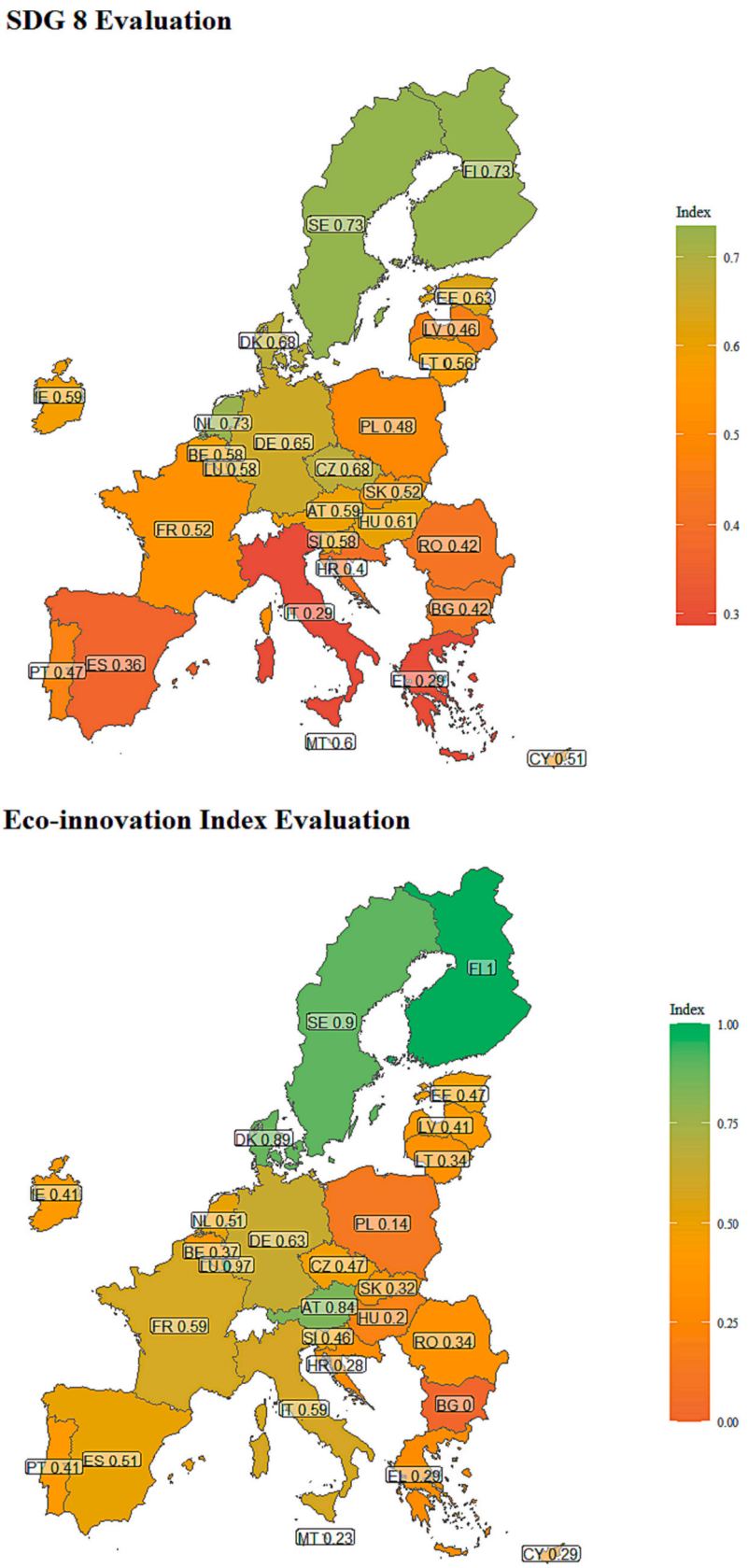

Fig. 1. Visualization of SDG 8 Evaluation and Eco-innovation Index Evaluation Outcomes.

Table 7
Outputs of selected regression models – SDG 8 Evaluation and Eco-innovation Index Evaluation.

Statistic	OLS coefficient [st. error] p-value	SLX coefficient [st. error] p-value	SAR coefficient [st. error] p-value	SEM coefficient [st. error] p-value
Intercept	0.423 [0.046] <0.001	0.522 [0.102] <0.001	0.739 [0.223] <0.001	0.428 [0.040] <0.001
Eval EII	0.246 [0.085] 0.008	0.255 [0.085] 0.006	0.258 [0.078] <0.001	0.237 [0.079] 0.003
lag.Eval EII	–	−0.247 [0.229] 0.290	–	–
rho	–	–	−0.607 [0.413] 0.142	–
lambda	–	–	–	−0.322 [0.427] 0.450
R2	0.253	0.287	–	–
R2 Adj.	0.223	0.228	–	–
AIC	−38.3	−37.5	−38.0	−36.8
BIC	−34.4	−32.4	−32.9	−31.6
RMSE	0.11	0.10	0.10	0.11

Note: Shapiro–Wilk normality test: W = 0.9423, p-value = 0.1442; Breusch–Pagan test: BP = 0.0527, *p*-value = 0.8185; global Moran I: Moran I statistic standard deviate = −0.26589, p-value = 0.6048; Lagrange multiplier diagnostics for spatial dependence: RLMlag = 1.2565, p-value = 0.2623; Spatial Hausman test (asymptotic): Hausman test = −0.1053, p-value = 0.9487.

position. The countries were divided into two clusters through the cluster analysis application (Fig. 2). The interpretation is that the higher the rating value, the more positive the result. Similarly, the countries with the highest values are placed in the upper right corner, and those with the lowest are in the lower left corner. The countries in Northern Europe (Denmark, Sweden, and Finland) can be included among the countries with the best rating. On the opposite side, Greece can be identified. From the point of view of the overall assessment of SDG 8, Greece and Italy have the worst assessment among all the EU countries. The worst-rated country regarding eco-innovation is Bulgaria. When interpreting, paying attention to the countries whose position outside the clusters indicates relatively significant deviations is appropriate. These countries, Italy and Bulgaria, belong to the red cluster. Their localization outside the cluster visualization indicates specific differences compared to the countries in the same cluster.

5. Discussion and policy implications

The study's main goal was to analyze and quantify the relationships between the selected categories of eco-innovations and SDG 8 within the 27 EU countries. Several analytical procedures were implemented, and answers to individual research questions were obtained. This approach enabled the creation of a discussion platform and recommendations for policymakers.

The outcomes of the descriptive analysis yielded several interesting findings. Among the selected sectors, investments in the business sector had the largest average share of eco-innovations. In general, female unemployment is slightly higher than male unemployment. On the contrary, a higher rate of fatal work accidents was found for men. The most significant variability was manifested in the year-on-year change in GDP. Employment of men and women appears to be the most stable.

5.1. The relationship between eco-innovations and inclusive and sustainable economic growth

The research question RQ1, aimed at assessing the relationship between eco-innovations and GDP, can be answered positively, and the assessed relationship is significant. Furthermore, a higher level of GDP per capita can be associated with a higher value of eco-innovations. Conversely, the year-on-year change in GDP showed a negative relationship that does not need to be perceived negatively. Neither an excessively high nor a low level of year-on-year change in GDP is suitable for the countries' economies. These results are also influenced by

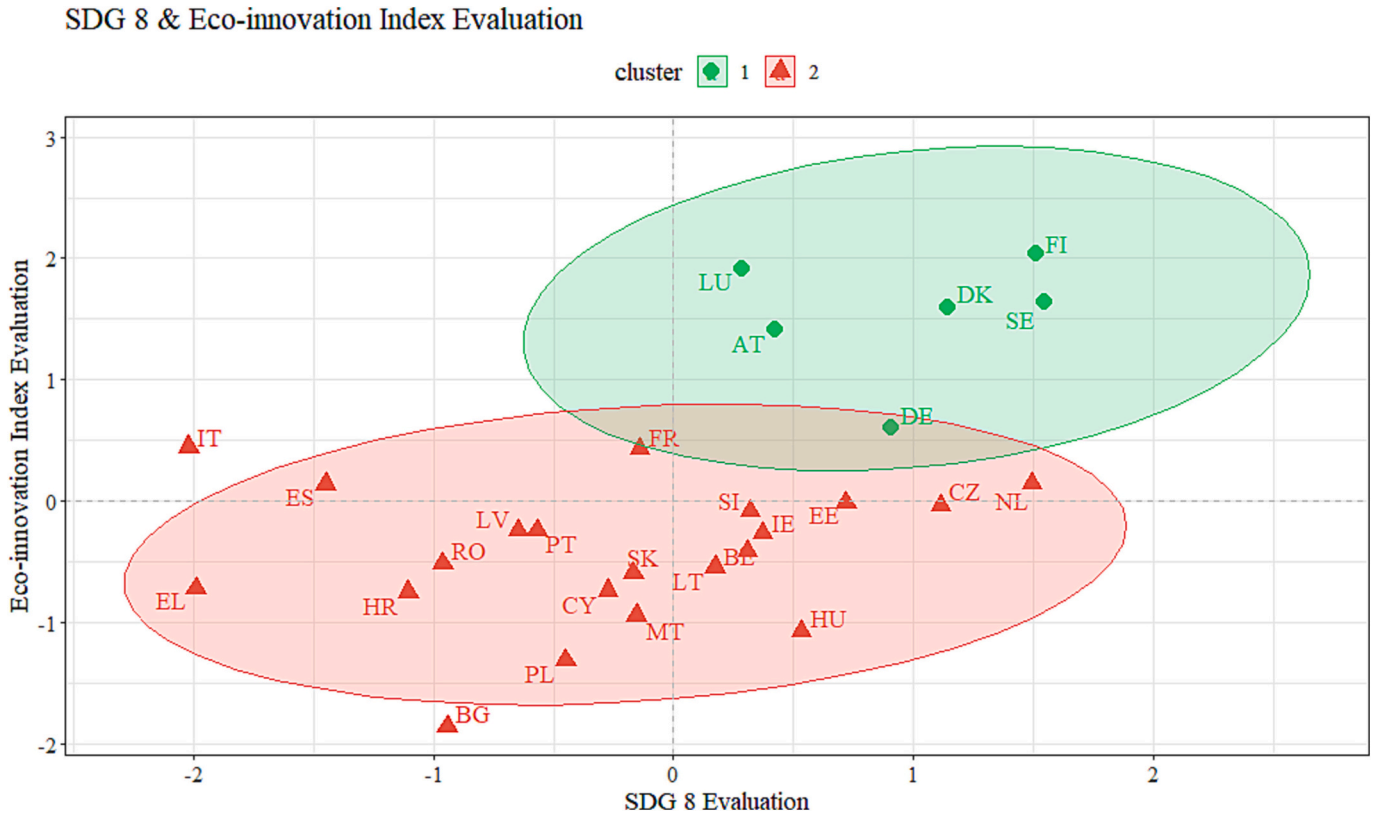

Fig. 2. Cluster Map of SDG 8 Evaluation and Eco-innovation Index Evaluation.

the long-term development of the European countries' political, economic, and social systems that impacted the environment, capital, and eco-innovations (Istrate et al., 2019).

These findings fully correspond to the results of the study by Mačiulytė-Šniukienė and Sekhniashvili (2021), which confirms the impact of the eco-innovations on economic growth and environmental performance within the EU countries, while this impact was also confirmed outside the EU (Sun et al., 2021; Istrate et al., 2019). Many studies confirm the high correlation between GDP and eco-innovations (Andabaka et al., 2019). At the same time, this trend will be unsustainable unless high-quality environmental monitoring among the countries is ensured and eco-innovation strategies are adopted (Qureshi et al., 2022). The R&D parameters will also play an important role by increasing the number of R&D employees and researchers, eco-innovation patents, and sustainable products (Hajdukiewicz and Pera, 2023). The structural differences in R&D funding in the EU countries will significantly influence the introduction of eco-innovations (Jesic et al., 2021).

The research question RQ2 focused on investments. It was found that the eco-innovations significantly affect only household investments. With a higher level of eco-innovations, it is possible to expect a higher level of household investment. Investment in the business and government sectors did not show sufficient significance level. These findings are confirmed by the results of the study by Ahsan et al. (2023) and Ma et al. (2022), who also draw attention to the need to examine financial inclusion and exports to reduce emissions. A higher rate of business and government sector investments in eco-innovations is also related to proactive eco-innovations, whose impact on the financial performance of enterprises and SDGs is not sufficiently explored (Johl and Toha, 2021).

5.2. The relationship between the eco-innovations, productive employment, and decent work for all

The results associated with the research question RQ3, which was focused on the area of employment concerning SDG 8, show that an increase in eco-innovations can lead to a decrease in unemployment. Eco-innovations represent the closest relationship to increased employment or reduced unemployment. These results are also confirmed by the study of Gagliardi et al. (2016). At the same time, the authors emphasize the significant impact of patents in eco-innovations on long-term employment growth. The process and organizational changes in enterprises will also be related to the growth of employment caused by the eco-innovations, which are also confirmed by Balconi et al. (2019), Macke and Genari (2019), and Bucea-Manea-Ţoniş et al. (2021). Horbach et al. (2012) also state that eco-innovation stimulates employment growth more than product eco-innovations, which will also impact the creation of sectoral policies.

As a part of the investigation of the relationship between eco-innovations and fatal accidents (RQ4), the negative aspect of eco-innovations was evaluated. A negative relationship was confirmed for both men and women, meaning ecological innovations cannot be associated with a higher rate of accidents. Nevertheless, the negative significant rate was manifested for men only, primarily because men work in riskier positions more often than women. More intensive investigation of risks in the work processes related to innovative transformations of industries and enterprises will be critical. Many research studies highlight the risks of using new materials, technologies, and eco-innovation models. These risks are related to using environmentally friendly materials (e.g., renewable, recycled materials, nanomaterials, and so on). They are caused by the use of new eco-technologies (materials and methods applied in the ecological supply of electricity and water in the reduction of waste and emissions), or they arise as a part of new ecological projects (Smol et al., 2017; Ansah and Sorooshian, 2017). When investigating the relationship between work accidents and the eco-innovations, it is necessary to take into account sector differentiation, which is pointed out by many authors investigating green workplaces (Santos et al., 2015; Sehnem et al., 2016) or green building, which is considered a risky activity (Zhang and Mohandes, 2020).

From the outcomes of the analytical processes associated with RQ5, in which the significance of the relationship between the Eco-innovation Index and employed at risk-of-poverty was investigated, a significant relationship exists between these variables. In countries with a higher eco-innovation rate, a lower poverty risk rate among workers prevails. Hence, eco-innovations demonstrate a strong potential to improve employees' standard of living. The stated findings also correspond with the results of the study by Carlsen (2021), who, when examining the achievement of SDG 8, draws attention to the differences in the unemployment of the EU countries and their development with an emphasis on gender differentiation. So far, no studies have examined the effect of eco-innovations on structural changes in employment and their social impacts, which are necessary for creating policies. Effective personnel policies and policies aimed at the labor market will allow us to eliminate the unemployment processes. Companies' eco-innovation strategies will also play an essential role in this process. As Kunapatarawong and Martínez-Ros (2016) reported, the voluntary eco-innovations of enterprises promote employment development, while no relationship has been confirmed between employment and the eco-innovations of the policy-regulated enterprises. Therefore, examining the effects of the policies on the eco-innovative development of enterprises and their economic and social impacts has become increasingly important.

5.3. The eco-innovations and green economy

The research question RQ7 investigated the relationship between the Eco-innovation Index and the consumption of raw materials, proving no significant relation. As confirmed by the results of the study by Istrate et al. (2019), the countries of Central and Eastern Europe show inefficient use of materials, water, and energy resources, as well as low resource productivity. These aspects will negatively affect the development of the Eco-innovation Index values in the future and the environmental sustainability of the countries. An important aspect of eco-innovations will also be their cost-effectiveness and the availability of critical raw materials, which should be a part of the evaluation dimensions of the sustainable strategies within green finance (Martins and Castro, 2020; Lasisi et al., 2022). As reported by Malehmir et al. (2019), the European innovation partnerships for raw materials will also play an essential role in eco-innovative development focused on consuming raw materials.

The analytical processes of the aggregated SDG 8 Evaluation indicators and the Eco-innovation Index demonstrated a significant relationship. The results show that the Eco-innovation Index positively affects the aggregated value. In the countries with a higher level of the Eco-innovation Index, a higher level of aggregated SDG 8 was also identified, meaning that with an increase in the Eco-innovation Index, better achievement of SDG 8 can be expected.

The cluster analysis outcomes made it possible to evaluate the countries' position within the scope of the values achieved by eco-innovations and SDG 8. The countries in Northern Europe achieved the most favorable evaluation. Bulgaria and Poland can be included among the countries with the lowest eco-innovation rate. Among the countries with the lowest rate of evaluation of SDG 8, it is possible to include, for instance, Greece, Italy, and Spain. Bulgaria and Romania demonstrate low investments in integrated waste management and low recycling rates; hence, waste management and pollution are serious environmental threats in these countries (Istrate et al., 2019). Solving this problem could also be supported by higher financial integration of the countries, which will support better financing of the projects within the framework of the eco-innovations and their relationships with energy transformation and environmental sustainability (Zhang, 2023), accelerating the economic growth of the countries (Ahmad et al., 2021).

For this reason, it is important when evaluating the countries in the field of eco-innovations to examine their economic development and the transformation processes that took place. Visible differences occur between Western and Northern European countries, even though these countries achieve long-term performance in eco-innovations (Jesic et al., 2021; Vieira and Radonjič, 2020). In the postcrisis period, eco-innovation development in these countries has grown slowly. The Mediterranean countries were the most affected by the economic recession, which significantly affected their approach to eco-innovations. The countries of Central and Eastern Europe affected by the postcommunist transformation had to tackle many economic and social problems, which negatively affected the adoption of eco-innovations (Istrate et al., 2019; Häggmark and Elofsson, 2022). The previous reforms and the support mechanisms for introducing green finance and eco-innovations also influence the differences between the countries. The political effects, which have regional heterogeneity (Hou et al., 2023), as well as the European environmental policies (Puertas et al., 2022) and the national innovation policies (Kraus et al., 2021), also play an important role.

5.4. Policy implications

The countries face difficult challenges concerning achieving the SDGs. One of the solutions is the preparation of the optimal strategies when designing green portfolios in the financial industry. The green portfolios focus on environmental returns, diminishing the negative impacts of climate change through low-carbon programs, minimizing pollution, and making the resources more efficient. The regulatory processes from the financial and legislative bodies of the individual countries will play an important role. Some studies show that the portfolios of green investments closely linked to the SDGs have proliferated (Rizzello, 2022). In addition to innovative green technologies, green finance can also support the development of green businesses, in which the impact of risks and environmental incentives will be considered in the decision-making processes. Green finance can improve the environmental and social performance of green businesses and, thus, support the sustainability processes (Xu, 2023; Škare et al., 2022).

In the future, it will be necessary to focus more on researching the relationships between eco-innovations and employment at the level of the individual sectors and enterprises and, thus, to analyze the determinants of the successful transformation processes and barriers associated with the eco-innovations (such as the processes of digital transformation and the CE) on the voluntary and policy-driven eco-innovations of enterprises, proactive and reactive eco-innovation strategies of enterprises, and so on. Several authors have pointed out the missing sectoral studies for a long time (Ronaldo and Suryanto, 2022; Terzic, 2022).

As the European countries are characterized by technological and institutional heterogeneity, it will be necessary to systematically develop the eco-innovation indices to create a comparative base and reveal innovation potential and barriers in the individual countries. This approach will also help in the processes of creating stabilization and regulatory mechanisms for the governments to support eco-innovative development and to mitigate the adverse effects of the transformation processes in the sectors and enterprises, as well as in the creation of effective policies aimed at achieving the SDGs and stable economic growth.

5.5. Research limitations and topics for further direction

When interpreting the results, drawing attention to certain limitations is necessary. The first is that the databases were incomplete and had missing data. An unavoidable limitation is also associated with the problem of endogeneity, where it is necessary to point out that the interpretations should not be perceived in the intentions of a causal relation; however, we assumed that these shortcomings would not significantly disrupt or distort the overall results. Our future research will focus primarily on employment and green investments, while its goal will be a more detailed examination of these components concerning green finance and the eco-innovations within the sectors and enterprises.

6. Conclusion

According to the current development and the strategies and goals of the 2030 agenda, an increasingly important role of eco-innovations in the countries' economies is expected. Eco-innovations will increasingly contribute to the green and sustainable growth of all EU countries and thus ensure their competitiveness and reduce the economic and social differences between them.

Green finance represents one of the effective forms of supporting the eco-innovative development of the countries. The governments of the countries and the international institutions face significant challenges to ensure the management of high-quality green investments within the framework of green finance and to set up suitable mechanisms for risk prevention.

The study's main goal was to analyze and quantify the relationships between selected categories of eco-innovations and SDG 8 in the EU countries. The data from the 27 EU countries were analyzed from 2013 to 2022. Several aspects of SDG 8 were analyzed through the seven research questions and applying the regression and cluster analysis.

The outcomes of the analytical processes revealed some relations between the selected SDG 8 indicators and the ecological innovations. The positive relationship between the eco-innovations and the employment indicators within the EU countries was highlighted. The study outcomes also appeal to the insufficiently researched issue regarding the effects of eco-innovations on employment at the level of enterprises and sectors, the proactive eco-innovations on employment, and the eco-innovations of processes and products on employment. We confirmed that a higher rate of business and government sector investments in eco-innovations is also related to proactive eco-innovations. They cannot be associated with a higher work accident rate, while they affect only household investments. No significant relation was found between the Eco-innovation Index and the consumption of raw materials. The Eco-innovation Index has a positive effect on the aggregated value. In the countries with a higher rate of the Eco-innovation Index, a higher rate of the aggregated SDG 8 was also identified.

The study outcomes are beneficial for policymakers, strategic development plans, and for setting the optimal decision-making and regulatory processes. They will allow us to focus on areas that ensure countries' compliance with SDG 8. This study also declares the importance of examining the relative impact of the individual indicators for achieving SDG 8. This work eliminates the shortcomings of the available studies applying subjective aggregation of the indicators within the multiindicator systems analysis.

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CRediT authorship contribution statement

Ramon Arilla-Llorente: Writing – review & editing, Validation, Supervision, Resources, Formal analysis, Data curation, Conceptualization. **Beata Gavurova:** Writing – review & editing, Writing – original

draft, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization. **Martin Rigelsky:** Visualization, Validation, Software, Resources, Formal analysis, Data curation. **Domingo Ribeiro-Soriano:** Writing – review & editing, Writing – original draft, Validation, Supervision, Formal analysis, Data curation, Conceptualization.

Declaration of Competing Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.eneco.2023.107280.

References

Ahmad, M., Wu, Y., 2022. Combined role of green productivity growth, economic globalization, and eco-innovation in achieving ecological sustainability for OECD economies. J. Environ. Manag. 302, 113980 https://doi.org/10.1016/j.jenvman.2021.113980.

Ahmad, M., Jiang, P., Murshed, M., Shehzad, K., Akram, R., Cui, L., Khan, Z., 2021. Modelling the dynamic linkages between eco-innovation, urbanization, economic growth and ecological footprints for G7 countries: does financial globalization matter? Sustain. Cities Soc. 70, 102881 https://doi.org/10.1016/j.scs.2021.102881.

Ahsan, T., Al-Gamrh, B., Qureshi, M.A., Gull, A.A., 2023. Does eco-innovation foster or hinder environmental performance? Recent evidence from Europe. Int. J. Green Energy 1–11. https://doi.org/10.1080/15435075.2023.2194982.

Andabaka, A., Basarac Sertić, M., Harc, M., 2019. Eco-innovation and economic growth in the European Union. Zagreb. Int. Rev. Econ. Bus. 22 (2), 43–54. https://doi.org/10.2478/zireb-2019-0019.

Ansah, R.H., Sorooshian, S., 2017. Effect of lean tools to control external environment risks of construction projects. Sustain. Cities Soc. 32, 348–356. https://doi.org/10.1016/j.scs.2017.03.027.

Araújo, N., Cardoso, L., Fraiz Brea, J.A., De Araújo, A.F., 2018. Green jobs: the present and future of the building industry. Evol. Anal. Soc. Sci. 7 (12), 266. https://doi.org/10.3390/socsci7120266.

Arranz, N., Arroyabe, F., Fernandez de Arroyabe, J.C., 2019. The effect of regional factors in the development of eco-innovations in the firm. Bus. Strateg. Environ. 28 (7), 1406–1415. https://doi.org/10.1002/bse.2322.

Balconi, M., Venturella, I., Fronda, G., Vanutelli, M.E., 2019. Leader-employee emotional "interpersonal tuning". An EEG coherence study. Soc. Neurosci. 15 (2), 234–243. https://doi.org/10.1080/17470919.2019.1696226.

Berrou, R., Dessertine, P., Migliorelli, M., 2019. An overview of green finance. In: Migliorelli, M., Dessertine, P. (Eds.), The Rise of Green Finance in Europe. Palgrave Studies in Impact Finance. Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-030-22510-0_1.

Bossle, M.B., de Barcellos, M.D., Vieira, L.M., Sauvée, L., 2016. The drivers for adoption of eco-innovation. J. Clean. Prod. 113, 861–872. https://doi.org/10.1016/j.jclepro.2015.11.033.

Bucea-Manea-Țoniș, R., Prokop, V., Ilic, D., Gurgu, E., Bucea-Manea-Țoniș, R., Braicu, C., Moanță, A., 2021. The relationship between eco-innovation and smart working as support for sustainable management. Sustainability 13 (3), 1437. https://doi.org/10.3390/su13031437.

Carlsen, L., 2021. Decent work and economic growth in the European Union. A partial order analysis of Eurostat SDG 8 data. Green Fin. 3 (4), 483–494. https://doi.org/10.3934/gf.2021022.

Chatzistamoulou, N., Koundouri, P., 2020. Exploring the Patterns of Eco-Innovation Index and Competitiveness Index in Europe. Working Papers. Athens University of Economics and Business. https://EconPapers.repec.org/RePEc:aue:wpaper:2011.

Chien, F., 2023. The impact of green investment, eco-innovation, and financial inclusion on sustainable development: evidence from China. Eng. Econ. 34 (1), 17–31. https://doi.org/10.5755/j01.ee.34.1.32159.

Costantini, V., Delgado, F.J., Presno, M.J., 2023. Environmental innovations in the EU: a club convergence analysis of the eco-innovation index and driving factors of the clusters. Environ. Innov. Soc. Trans. 46, 100698 https://doi.org/10.1016/j.eist.2023.100698.

Divella, M., Sterlacchini, A., 2021. Determinants of sustainable & responsible innovations: a firm-level analysis for Italy. Struct. Chang. Econ. Dyn. 59, 360–374. https://doi.org/10.1016/j.strueco.2021.09.011.

European Commission, 2018. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Action Plan: Financing Sustainable Growth, COM(2018) 97 Final.

European Commission, 2019. The European Green Deal, COM(2019) 640 Final.

European Commission, 2021a. Commission Puts Forward New Strategy to Make the EU's Financial System more Sustainable and Proposes New European Green Bond Standard, Press Release.

European Commission, 2021b. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Strategy for Financing the Transition to a Sustainable Economy, COM(2021) 390 Final.

European Commission, 2023. Eco-Innovation at the Heart of European Policies. https://green-business.ec.europa.eu/eco-innovation_en.

Eurostat, 2023. Sustainable Development Goals 8. Decent Work and Economic Growth. https://ec.europa.eu/eurostat/web/sdi/database/decent-work-and-economic-growth.

Ferasso, M., Beliaeva, T., Kraus, S., Clauss, T., Ribeiro-Soriano, D., 2020. Circular economy business models: the state of research and avenues ahead. Bus. Strateg. Environ. 29 (8), 3006–3024. https://doi.org/10.1002/bse.2554.

Francesco, V., Marin, G., Consoli, D., Popp, D., 2018. Environmental regulation and green skills: an empirical exploration. J. Assoc. Environ. Resour. Econ. 5, 713–753. https://doi.org/10.1086/698859.

Gagliardi, L., Marin, G., Miriello, C., 2016. The greener the better? Job creation effects of environmentally-friendly technological change. Ind. Corp. Chang. 25 (5), 779–807. https://doi.org/10.1093/icc/dtv054.

Gervais, E., Shammugam, S., Friedrich, L., Schlegl, T., 2021. Raw material needs for the large-scale deployment of photovoltaics–effects of innovation-driven roadmaps on material constraints until 2050. Renew. Sust. Energ. Rev. 137, 110589 https://doi.org/10.1016/j.rser.2020.110589.

Hafner, S., Jones, A., Anger-Kraavi, A., Pohl, J., 2020. Closing the green finance gap–a systems perspective. Environ. Innov. Soc. Trans. 34, 26–60. https://doi.org/10.1016/j.eist.2019.11.007.

Häggmark, T., Elofsson, K., 2022. The drivers of private and public eco-innovations in six large countries. J. Clean. Prod. 364, 132628 https://doi.org/10.1016/j.jclepro.2022.132628.

Hajdukiewicz, A., Pera, B., 2023. Eco-innovation in the European Union: challenges for catching-up economies. Entrepreneurial Bus. Econ. Rev. 11 (1) https://doi.org/10.15678/eber.2023.110108.

Haslam, R.A., Hide, S.A., Gibb, A.G., Gyi, D.E., Pavitt, T., Atkinson, S., Duff, A.R., 2005. Contributing factors in construction accidents. Appl. Ergon. 36 (4), 401–415. https://doi.org/10.1016/j.apergo.2004.12.002.

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. Ecol. Econ. 78, 112–122. https://doi.org/10.2139/ssrn.1805765.

Hou, H., Zhu, Y., Wang, J., Zhang, M., 2023. Will green financial policy help improve China's environmental quality? The role of digital finance and green technology innovation. Environ. Sci. Pollut. Res. 30, 10527–10539. https://doi.org/10.1007/s11356-022-22887-z.

Istrate, M., Horea-Serban, R., Banica, A., 2019. Progress in eco-innovation for green and resilient development in European Union with a focus on central and eastern European countries. J. Environ. Prot. Ecol. 20 (4), 1814–1821.

Jesic, J., Okanovic, A., Panic, A.A., 2021. Net zero 2050 as an EU priority: modelling a system for efficient investments in eco innovation for climate change mitigation. Energy Sustain. Soc. 11 https://doi.org/10.1186/s13705-021-00326-0, 50(2021).

Jo, J.H., Roh, T.W., Kim, S., Youn, Y.C., Park, M.S., Han, K.J., Jang, E.K., 2015. Eco-innovation for sustainability: evidence from 49 countries in Asia and Europe. Sustainability 7 (12), 16820–16835. https://doi.org/10.3390/su71215849.

Johl, S.K., Toha, M.A., 2021. The Nexus between proactive eco-innovation and firm financial performance: a circular economy perspective. Sustainability 13 (11), 6253. https://doi.org/10.3390/su13116253.

Kesidou, E., Demirel, P., 2012. On the drivers of eco-innovations: empirical evidence from the UK. Res. Policy 41 (5), 862–870.

Kraus, S., McDowell, W., Ribeiro-Soriano, D.E., Rodríguez-García, M., 2021. The role of innovation and knowledge for entrepreneurship and regional development. Entrepreneurship Reg. Develop. 33 (3–4), 175–184. https://doi.org/10.1080/22797254.2021.1872929.

Kunapatarawong, R., Martínez-Ros, E., 2016. Towards green growth: how does green innovation affect employment? Res. Policy 45 (6), 1218–1232. https://doi.org/10.1016/j.respol.2016.03.013.

Larbi-Siaw, O., Xuhua, H., Owusu, E., Owusu-Agyeman, A., Fulgence, B.E., Frimpong, S. A., 2022. Eco-innovation, sustainable business performance and market turbulence moderation in emerging economies. Technol. Soc. 68, 101899 https://doi.org/10.1016/j.techsoc.2022.101899.

Lasisi, T.T., Alola, A.A., Muoneke, O.B., Eluwole, K.K., 2022. The moderating role of environmental-related innovation and technologies in growth-energy utilization nexus in highest-performing eco-innovation economies. Technol. Forecast. Soc. Chang. 183, 121953 https://doi.org/10.1016/j.techfore.2022.121953.

Ma, Q., Han, X., Badeeb, R.A., Khan, Z., 2022. On the sustainable trade development: do Financial inclusion and eco-innovation matter? Evidence from method of moments quantile regression. Sustain. Dev. 30 (5), 1044–1055. https://doi.org/10.1002/sd.2298.

Mac Lennan, M.L.F., Tiago, E.F., Pereira, C.E.C., 2023. Technological and non-technological trends in fashion eco-innovations. Innovat. Manag. Rev. 20 (1), 60–75. https://doi.org/10.1108/INMR-12-2020-0177.

Mačiulytė-Šniukienė, A., Sekhniashvili, D., 2021. The eco-innovation impact on economic and environmental performance of EU member states. Bus. Manag. Econ. Eng. 19 (2), 212–228. https://doi.org/10.3846/bmee.2021.14497.

Macke, J., Genari, D., 2019. Systematic literature review on sustainable human resource management. J. Clean. Prod. 208, 806–815. https://doi.org/10.1016/j.jclepro.2018.10.091.

Mahmood, N., Zhao, Y., Lou, Q., Geng, J., 2022. Role of environmental regulations and eco-innovation in energy structure transition for green growth: evidence from OECD. Technol. Forecast. Soc. Chang. 183, 121890 https://doi.org/10.1016/j.techfore.2022.121890.

Malehmir, A., Holmes, P., Gisselø, P., Socco, L.V., Carvalho, J., Marsden, P., Verboon, A. O., Loska, M., 2019. Smart exploration: Innovative ways of exploring for the raw materials in the EU. In: 81st EAGE Conference and Exhibition 2019, 1, 1–5. European Association of Geoscientists & Engineers. https://doi.org/10.3997/2214-4609.201901668.

Martins, F.F., Castro, H., 2020. Raw material depletion and scenario assessment in European Union–a circular economy approach. Energy Rep. 6, 417–422. https://doi.org/10.1016/j.egyr.2019.08.082.

Mauler, L., Lou, X., Duffner, F., Leker, J., 2022. Technological innovation vs. tightening raw material markets: falling battery costs put at risk. Energy Adv. 1 (3), 136–145. https://doi.org/10.1039/d1ya00052g.

Muszyński, Z., Kozioł, L., Muszyński, J., 2011. Selected issues in innovativeness in forestry processes management. Zeszyty Naukowe Małopolskiej Wyższej Szkoły Ekonomicznej w Tarnowie 2 (19), 75–85.

Orlando, B., Ballestra, L.V., Scuotto, V., Pironti, M., Del Giudice, M., 2020. The impact of R&D investments on eco-innovation: a cross-cultural perspective of green technology management. IEEE Trans. Eng. Manag. 69 (5), 2275–2284. https://doi.org/10.1109/tem.2020.3005525.

Pakulska, J., 2021. The eco-innovation versus economic development on the EU example. Eur. Res. Stud. J. 24 (1), 999–1008. https://doi.org/10.35808/ersj/2007.

Passaro, R., Quinto, I., Scandurra, G., Thomas, A., 2023. The drivers of eco-innovations in small and medium-sized enterprises: a systematic literature review and research directions. Bus. Strateg. Environ. 32 (4), 1432–1450. https://doi.org/10.1002/bse.3197.

Peyravi, B., Peleckis, K., Jakubavičius, A., 2023. Eco-innovation performance of lithuania in the context of European environmental policy: eco-innovation indicators and efficiency. Sustainability 15 (4), 3139. https://doi.org/10.3390/su15043139.

Platon, V., Pavelescu, F.M., Surugiu, M., Frone, S., Mazilescu, R., Constantinescu, A., Popa, F., 2023. Influence of eco-innovation and recycling on raw material consumption; econometric approach in the case of the European Union. Sustainability 15 (5), 3996. https://doi.org/10.3390/su15053996.

Puertas, R., Marti, L., 2021. Eco-innovation and determinants of GHG emissions in OECD countries. J. Clean. Prod. 319, 128739 https://doi.org/10.1016/j.jclepro.2021.128739.

Puertas, R., Guaita-Martinez, J.M., Carracedo, P., Ribeiro-Soriano, D., 2022. Analysis of European environmental policies: improving decision making through eco-efficiency. Technol. Soc. 70, 102053 https://doi.org/10.1016/j.techsoc.2022.102053.

Qureshi, M.A., Ahsan, T., Gull, A.A., 2022. Does country-level eco-innovation help reduce corporate CO2 emissions? Evidence from Europe. J. Clean. Prod. 379, 134732 https://doi.org/10.1016/j.jclepro.2022.134732.

Rathnayake, U., Karunasena, G., 2016. Review of strategies to improve workplace safety through ethical climates. In: Sandanayake, Y.G., Karunasena, G.I., Ramachandra, T. (Eds.), Greening Environment, Eco-Innovations & Entrepreneurship. Ceylon Institute of Builders, pp. 389–398. In: https://ciobwcs.com/downloads/WCS2016-Proceedings.pdf.

Rizzello, A., 2022. Green finance and SDGs: emerging trends in the design of green investment portfolios. In: Green Investing: Changing Paradigms and Future Directions, 85–105. https://doi.org/10.1007/978-3-031-08031-9_4.

Ronaldo, R., Suryanto, T., 2022. Green finance and sustainability development goals in Indonesian Fund Village. Res. Policy 78, 102839. https://doi.org/10.1016/j.resourpol.2022.102839.

Saha, T., Sinha, A., Abbas, S., 2022. Green financing of eco-innovations: is the gender inclusivity taken care of? Econ. Res. Ekonomska Istraživanja 35 (1), 5514–5535. https://doi.org/10.1080/1331677X.2022.2029715.

Santos, D.F.L., Basso, L.F.C., Kimura, H., Sobreiro, V.A., 2015. Eco-innovation in the Brazilian sugar-ethanol industry: a case study. Brazil. J. Sci. Technol. 2, 1–15. https://doi.org/10.1186/s40552-014-0006-4.

Sehnem, S., Lazzarotti, F., Bencke, F.F., 2016. Sustainable practices and eco-innovations adopted by industrial companies. Int. J. Innovat. 4 (2), 42–58. https://doi.org/10.5585/iji.v4i2.106.

Škare, M., Blažević Burić, S., Sinković, D., 2022. Effects of energy prices shocks on global inflation: a panel structural VAR approach. Acta Montan. Slovaca 27 (4), 929–943. https://doi.org/10.46544/ams.v27i4.08.

Smol, M., Kulczycka, J., Avdiushchenko, A., 2017. Circular economy indicators in relation to eco-innovation in European regions. Clean Techn. Environ. Policy 19, 669–678. https://doi.org/10.1007/s10098-016-1323-8.

Soundarrajan, P., Vivek, N., 2016. Green finance for sustainable green economic growth in India. Agricult. Econ. (Zemědělská ekonomika) 62, 35–44. https://doi.org/10.17221/174/2014-agricecon.

Su, C.W., Umar, M., Khan, Z., 2021. Does fiscal decentralization and eco-innovation promote renewable energy consumption? Analyzing the role of political risk. Sci. Total Environ. 751, 142220 https://doi.org/10.1016/j.scitotenv.2020.142220.

Sun, Y., Yesilada, F., Andlib, Z., Ajaz, T., 2021. The role of eco-innovation and globalization towards carbon neutrality in the USA. J. Environ. Manag. 299, 113568 https://doi.org/10.1016/j.jenvman.2021.113568.

Terzic, L., 2022. Towards European Union's green deal: the importance of sustainable competitiveness and eco-innovation for achieving prosperity in EU-27 member states. Uluslararası Ekonomi ve Yenilik Dergisi 8 (2), 195–218. https://doi.org/10.20979/ueyd.1100207.

Vieira, A.P., Radonjič, G., 2020. Disclosure of eco-innovation activities in European large companies' sustainability reporting. Corp. Soc. Responsib. Environ. Manag. 27 (5), 2240–2253. https://doi.org/10.1002/csr.1961.

Vona, F., Marin, G., Consoli, D., Popp, D., 2018. Environmental regulation and green skills: an empirical exploration. J. Assoc. Environ. Resour. Econ. 5 (4), 713–753. https://doi.org/10.1086/698859.

Wang, K.H., Zhao, Y.X., Jiang, C.F., Li, Z.Z., 2022. Does green finance inspire sustainable development? Evidence from a global perspective. Econ. Anal. Policy 75, 412–426. https://doi.org/10.1016/j.eap.2022.06.002.

Xu, X., 2023. Does green finance promote green innovation? Evidence from China. Environ. Sci. Pollut. Res. 30, 27948–27964. https://doi.org/10.1007/s11356-022-24106-1.

Yao, X., Wang, X., Xu, Z., Skare, M., 2022. Bibliometric analysis of the energy efficiency research. Acta Montan. Slovaca 27 (2), 505–521. https://doi.org/10.46544/ams.v27i2.17.

Zaman, R., Atawnah, N., Haseeb, M., Nadeem, M., Irfan, S., 2021. Does corporate eco-innovation affect stock price crash risk? Br. Account. Rev. 53 (5), 101031 https://doi.org/10.1016/j.bar.2021.101031.

Zhang, Y., 2023. The impact of energy transition and eco-innovation on environmental sustainability: a solution for sustainable cities and communities of top ten Asian countries. Eng. Econ. 34 (1), 32–45. https://doi.org/10.5755/j01.ee.34.1.32161.

Zhang, X., Mohandes, S.R., 2020. Occupational health and safety in green building construction projects: a holistic Z-numbers-based risk management framework. J. Clean. Prod. 275, 122788 https://doi.org/10.1016/j.jclepro.2020.122788.

Zhang, C., Lyu, R., Li, Z., MacMillen, S.J., 2021. Who should lead raw materials collection considering regulatory pressure and technological innovation? J. Clean. Prod. 298, 126762 https://doi.org/10.1016/j.jclepro.2021.126762.