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ECO-INNOVATIONS AND CIRCULAR ECONOMY DEVELOPMENT

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Abstract. The transition to a circular economy is of great importance to maintain the balance between quality of life and excessive consumption. In this regard, eco-innovations are established as a vital element for the development of business organizations and the economy. The main objective of the paper is to analyze and evaluate the trends in the development of the innovation activity of the EU countries and in particular Bulgaria in the field of eco-innovations. The results of different measurement are discussed, including eco-innovation index and some indicators related to circular economy in EU.

Keywords: eco-innovation; circular economy; sustainable development
JEL: *O30, Q55*

1. Introduction

Nowadays innovations are fundamental for the development of technology, increasing competitiveness and improving the quality of life of people. But they could also improve the environmental friendliness of a number of productions, lead to the saving of resources and energy, at the same time – improving the market positions of the companies that apply them. In this aspect indeed attention should be paid to the so-called eco-innovations and their huge importance for business and economy, but also for the whole society and its future. Their role in improving various products and processes and their qualities, design, utility and improved efficiency should also be highlighted here, especially in the context of the circular economy and sustainable development.

Unlike other approaches, strategies and practices applied by companies in market competition and the pursuit of greater profits, the implementation and application of eco-innovations in most cases does not achieve results at the expense of more resources and does not bring negatives to society, such as depleting resources too quickly, polluting the environment, etc. In fact, thanks to eco-innovations, positives are achieved, both for market subjects, such as higher efficiency and competitiveness, and for the whole society, in the form of saved raw materials and natural resources.

The aim of this scientific report is to examine and compare the performance of the EU Member States in terms of the eco-innovation index on the one hand and some indicators for assessing the achievements in the area of the circular economy, on the other, and to identify the main trends and dependencies between them.

2. Literature Review

Nature and characteristics of eco-innovations

A number of organizations (United Nations, 2024; European Commission, 2011) and authors (Carrillo-Hermosilla, del González & Könnölä, 2009; Stoyanova, 2021 and others) give definitions of eco-innovation, but one of the most popular of them is that "eco-innovation is a new business approach that promotes sustainability throughout the product lifecycle, while increasing the efficiency and competitiveness of the company (UN Environment Programme, 2024)".

But many of those who wrote on the topic (Dahan & Yusof, 2020; Ozusaglam, 2012; Kiefer, Carrillo-Hermosilla & Del Río, 2019), classify eco-innovations in the same way as all other innovations, distinguishing them according to their radicality, subject, marketing significance and other characteristics. It would also be of interest to classify them according to the reasons underlying their realisation. From this point of view, eco-innovations could be distinguished into three groups, namely:

– Eco-innovations generated by national or supranational legal and regulatory requirements with an environmental focus. In these cases, if enterprises want to stay in a business or maintain or expand a market, they need to improve the characteristics of the products they produce or the technologies and processes used, making them much more environmentally friendly, which in the vast majority of cases leads to the deployment of eco-innovations.

– Eco-innovations caused by access to financial projects in the area of ecology – It is about financial programs to stimulate certain industries and branches, and the funds allocated are exclusively for environmental projects.

– Eco-innovations caused by the need to fully use raw materials in order to increase efficiency – this group includes all those innovations that are related to the introduction of waste-free technologies, recycling and treatment plants, production of environmentally friendly products, etc.

It can be summarized that while the first two varieties in this classification are based on administrative-normative coercion, regardless of national or supranational authorities, the last group has the strongest market orientation because it is based on the search for higher efficiency, combined with a responsible attitude towards the environment. It is the eco-innovations of the third group that are the most useful from the point of view of the circular economy, because naturally economic actors limit the consumption of various raw materials and valuable resources.

Nowadays eco-innovations and the circular economy are inextricably linked socio-economic categories. If in today's conditions of intensive economic processes and phenomena, the circular economy seeks to close the cycle of resources-production-consumption in order to significantly increase resource efficiency and preserve the eco-balance, so eco-innovations are looking for the way to implement this in the most effective and expedient way. Achieving this balance is a challenge both for individual enterprises and at national level and is based on balancing the elements of the triple efficiency concept – people, planet, profit.

At the heart of the link between the circular economy and eco-innovation is another socially significant concept – that of the life cycle of products and its application in terms of resource efficiency assessment, implemented in the research of different authors, in different sectors of the economy (Fahlstedt et al., 2024; Valencia-Barba et al., 2023; Mostafaei et al., 2023; Manco et al., 2023; Torrubia et al., 2024). It is of essential importance in the transition to a circular economy to seek optimization of resource efficiency and relevant costs at every stage of the life cycle – from product design, through production to consumption and subsequent waste treatment – stages in which eco-innovations inevitably find application. The process of implementing good practices in the area of circular economy is influenced by various factors and is associated with a number of challenges. At the enterprise level, as Ahmadov et al. (2024) note, four elements and the relationships between them are important: Environmental awareness; Stakeholder pressure; Internal barriers and orientation towards the goals and strategies pursued in the area of circular economy through closed systems or on the basis of more strategically oriented thinking (Circular economy orientation). According to other authors (Zott, Amit & Giesen, 2024), the key to the effective implementation of circular models and eco-innovations is the main characteristic of an organization's business model through the interaction between the following 5 elements: direction, goals, templates, stakeholders and constraints on the basis of which the questions "What?"; "How?"; "Who" and the most fundamental one – "Why?". According to Pei, Italia & Melazzini (2024, p.17), it is of great importance to separate circular design strategies from an ecosystem perspective, integrating the interests of multiple stakeholders in three directions: raw materials; products and product-oriented services and a result-oriented business model. At the national level, the circular economy model has a more social expression, as it determines the vitality of the population, but at the same time maintains the competitiveness of national economies. Although most of the national balance between resources, production and consumption depends on the actions of business structures and the market, the state, as the main regulator, develops and adopts a number of regulatory requirements and policies. They relate both to stimulating the environmental behavior of economic entities through the introduction of eco-innovations in product and

technological terms, as well as to minimizing the negative impact of excessively increased consumption. Moreover, at the heart of the current legislation in the EU Member States is the so-called 3R Framework, integrating Reduce, Reuse and Recycle strategies to increase the durability and repairability of products, as well as allow their reuse, recycling and safety in terms of dangerous substance content (Barkhausen, 2024, p. 25). Other authors (Yu et al., 2021) also pay special attention to the "Recover" strategy, as a complement to the already mentioned 3R Framework, adding to the model the importance of the waste management process in settlements.

In the literature there are numerous studies on the influence of various factors on the successful implementation of the circular economy. For example, Mattson, Pettersen, & Brattebø (2024) include as significant factors related to waste generation and related costs; recycling level; level of waste disposal by incineration; recycling efficiency, etc. Lukic (2024) also examines waste management processes at the settlement level, including as factors the dependence of imported materials, resource efficiency, energy from renewable energy sources, etc. For their part, Silvestri, Spigarelli & Tassinari (2020) propose a research model that distinguishes factors related to waste management, resource efficiency, competitiveness and social well-being of the population in three directions, namely Socio-health dimension; Economic dimension and Environmental dimension.

3. Methodological characteristics of the research

The research focuses on presenting in a comparative aspect the dynamics and interrelationship between the Eco-Innovation Index and various indicators measuring the performance of EU Member States in the area of circular economy. In order to achieve this, the implementation of the following stages is envisaged:

– Stage 1 – Selection of indicators in the area of circular economy with information on EU countries to be presented in comparative and analytical aspect to the eco-innovation index. The main criteria for the selection of indicators is that they cover the cycle from the consumption of materials, through the generation of waste as a result of economic activity to the level of recycling.

– Stage 2 – Ensuring commensurability between the indicators, including the eco-innovation index, by recalculating the values of the individual indicators in order to rank the countries according to their performance and determine their relative position to each other according to equation 1:

$$S = 6 \times \frac{V_{i_k} - V_{i_{min}}}{V_{i_{max}} - V_{i_{min}}} + 1$$

Equation 1

Source: Adapted from Velev (2004, p. 111)

Where:

S – score of the respective country on the relevant indicator

V_{ik} – value of indicator i for country k

V_{imin} – minimum value of indicator i for the entire population of countries

V_{imax} – maximum value of indicator i for the entire population of countries

Stage 3 – Summarizing the results at EU level, their graphical presentation and interpretation.

4. Main results

According to the literature review and the separate methodological bases of the study, the following indicators related to the circular economy have been identified as appropriate: Resource productivity; Recycling rate of municipal waste; Generation of municipal waste per capita and Greenhouse gases emissions from production activities. Resource productivity is measured as the ratio of Gross Domestic Product and Domestic Material Consumption and takes into account the efficiency of the raw materials used in production. Recycling rate of municipal waste is an indicator for reporting the relative share of recycled municipal waste in the total municipal waste generation. Generation of municipal waste per capita measures the waste generated in kilograms per capita and collected by or on behalf of municipal authorities. The last indicator included in the study takes into account the greenhouse gases generated as a result of economic activities per capita. On the other hand is the Eco-innovation index, which is approved by the European Commission and is based on 12 indicators, grouped into 5 areas: efforts and resources for the implementation of eco-innovations; implementation activities; results achieved; results in terms of resource efficiency and socio-economic results. The indicators mentioned above are part of the Eurostat database (Eurostat, 2024), while the eco-innovation index is maintained and made public by the European Commission (2024).

By applying equation 1, the relative position of each of the countries relative to the others in the respective indicator is determined. The results by indicators are as follows:

Eco-innovation index – Data for the period 2018-2022 show that Luxembourg alone occupies the first position in the eco-innovation index, followed by Finland. The third position has changed over the period, with Sweden in 2018 and 2019, Denmark in 2020 and 2021, and Austria in 2022. For the period being studied, Bulgaria is invariably in the last position. The average rating for the EU is 4.22 for 2018; 4.16 for 2019; 4.13 for 2020; 4.07 for 2021 and 4.15 for 2022 (out of a maximum of 7). There is an annual decline, but a closer look at the data shows that it is not due to deteriorating performance of Member States, but to a more serious increase in the minimum value of the set of countries (by an average of about 12% per year), compared to the growth of the maximum recorded value of the indicator

in the set of countries (average annual increase of about 1%), which can be reported as a positive trend in the direction of equalization of performance by individual countries.

Resource productivity – In the period 2018-2022, the first two positions in terms of indicator are occupied by Luxembourg and the Netherlands, with Luxembourg leading the way in the first two years of the period, and the Netherlands topping the ranking since 2020. From 2018 to 2020, Italy was positioned in third place, and in 2021 and 2022 it was replaced by Ireland. Bulgaria is again in last place, with the exception of 2020, when it is occupied by Romania, but only within this one-year period. In comparative terms, the amendment of the Resource productivity indicator annually follows the amendment of the Eco-Innovation Index, with the first and last positions in the ranking of countries being identical.

Recycling rate of municipal waste – During the period being studied, Germany (which has consistently occupied the first position over the years), Slovenia and Austria stand out as countries with the highest achievements in the area of recycling. In 2022, Austria was displaced from the third position by the Netherlands. For these countries, the average recycling rate is over 60%. Cyprus, Romania and Malta accounted for just over 11%, while Bulgaria ranked 19 to 22 in the study period (with an average recycling rate of around 32%), marking a comparative abandonment compared to the EU average. This indicator shows a trend of comparative relation with eco-innovations, i.e. countries with a higher level of waste recycling report an index of eco-innovations above the average level and vice versa – those where recycling is not sufficiently represented as a practice are positioned below the average level in terms of the eco-innovations used.

Generation of municipal waste per capita – Given the nature of the indicator, the estimates of the relative position of the countries have been calculated by adapting equation 1 in order to give the lower level of waste generation a higher rank to the country under study. The data show that in the EU with the least generated waste are Romania, Poland and Estonia, with Romania consistently occupying the first position with an average of about 290 kg. generated waste per capita per year. The last places are occupied by Luxembourg, Denmark and Austria with an average waste generation of about 770 kg. The position of Bulgaria varies from 5 to 8 over the years (on average about 426 kg of waste), and the country's performance in this direction is relatively stable during the period being studied. In the comparative aspect between the indicator and the eco-innovation index, two interesting trends are noticeable: 1) Considering the EU average estimates, a relatively similar change is observed for the period 2018-2022 with an almost identical average rate and 2) For individual countries, it is noticeable that those with less waste generation have a lower eco-innovation index and vice versa – countries with a higher volume of waste generated per capita are better positioned in eco-innovation.

Greenhouse gases emissions from production activities – Similar to the previous indicator, the estimates are calculated using reciprocal values, providing a better ranking of countries that generate smaller amounts of greenhouse gases. The first three places are occupied by Malta, Croatia and Sweden (with an average of about 4,200 kg per capita), and the last places are occupied by Luxembourg, Denmark and Ireland (with an average of about 12,900 kg per capita). Bulgaria is deteriorating its relative position, ranking 15th in 2018 and 21st in 2022 (with an average of about 7,500 kg of greenhouse gases). And with this indicator, it is noticeable that some of the countries that have a leading position in terms of the eco-innovation index generate a large amount of greenhouse gases. An exception to this are countries (e.g. Sweden, France and Spain), which are distinguished by a balanced performance in both directions (relatively low amount of gases and a high level of eco-innovation). At the same time, countries such as Poland and Bulgaria occupy a low relative position both in terms of eco-innovations and in terms of greenhouse gases generated per capita.

The EU average scores for the studied indicators and the eco-innovation index for the period 2018 – 2022 are presented in figure 1.

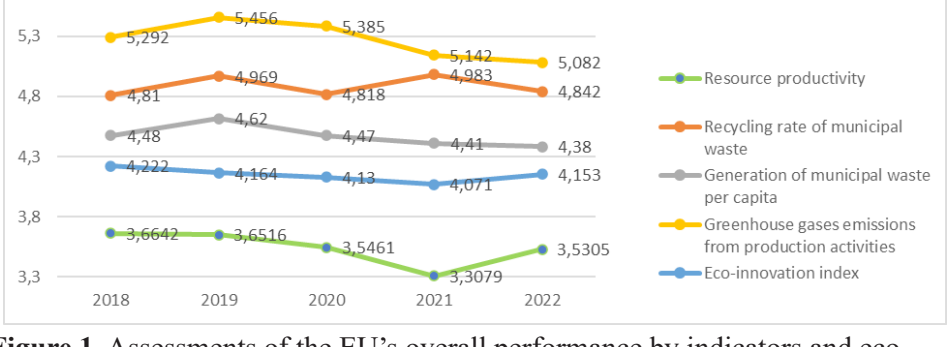

Figure 1. Assessments of the EU's overall performance by indicators and eco-innovation index for the period 2018 – 2022
Source: Compiled by the authors of a database from Eurostat and the European Commission

Based on the information presented and the findings, the following more important conclusions can be pointed:

First of all, the eco-innovation index is closely linked to the resource efficiency of the Member States' economies. Considering that, countries that are distinguished by a higher level of development, deployment and use of eco-innovations report better utilization of materials.

Second of all, Member States that are leading (above the EU average) according to the Eco-Innovation Index have a higher level of waste recycling. At the same time, they are the ones that generate a greater volume of waste per capita.

Last but not least, according to the level of greenhouse gas generation from economic activity within the EU, three groups of countries are formed: 1) those with the simultaneous development of eco-innovations and generating a large amount of greenhouse gases; 2) countries with a low level of implementation of eco-innovations and at the same time a large amount of greenhouse gases and 3) countries with a balanced performance in both directions.

5. Conclusion

At the end of the first quarter of the 21th century, the protection of the environment in which we live was perceived as particularly important for the whole EU. According to many specialists, business organizations and business people, the price to be paid to achieve a greener economy is related to the restriction of some production or loss of competitiveness. In fact, it is eco-innovation and the improvement of the elements of the circular economy that are among the most important factors that can improve the efficiency of entire traditional economic sectors and save thousands of jobs. In this regard, more efforts are required both from the business participants themselves and from the governments, especially the countries lagging behind in this area, which could offer more and more adequate measures both to stimulate eco-innovations, waste-free and low-waste production, as well as to improve recycling and more efficient waste processing.

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