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The Circular Economy Practices in the European Union: Eco-Innovation and Sustainable Development

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Abstract: This study examines whether there is convergence in eco-innovation by comparing the circular economy practices of European Union Member States. The European Union Member States' eco-innovation initiatives in the circular economy are the foundation for their interpretation of their relative efficiencies. In 2015, the European Commission granted sanction to the Circular Economy Package, in accordance with the European Union's (EU) objective of transitioning to a low-carbon economy that is competitive, resource-efficient, and environmentally sustainable. This compilation includes legislative proposals and a comprehensive action plan for refuse management. Subsequently, in January 2018, additional measures were implemented to guarantee the successful implementation of the action plan. Concurrently, numerous European Union Member States implemented substantial strategies to facilitate this transition. The current systematic literature review is conducted using the "SALSA method", which commences with a scoping search, progresses to an evaluation, and concludes with synthesis and analysis. Its purpose was to elucidate the circular economy practices and eco-innovation activities in the European Union. The objective of this assessment is to provide a concise overview of the most recent developments and initiatives that have been implemented in the European Union since the Circular Economy Package was adopted. Furthermore, it will evaluate the strategies implemented by particular Member States in this context. Methods of scientific literature analysis, including systematic, comparative, content analysis, grouping, comparison, SALSA, and TOPSIS methods, are used in this study.

Keywords: circular economy; eco-innovation; sustainability; sustainable development

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1. Introduction

Rapid population growth, technological progress, and globalization have all contributed to the emergence of production and consumption methods that disturb the natural equilibrium. Increasing environmental issues and the accelerated depletion of natural resources have brought the significance of sustainability to the forefront. For the attainment of success via sustainable development, concurrent progress is imperative in the economic, social, and environmental spheres. Urban areas are responsible for nearly two-thirds of the global energy demand, as well as 80% of global greenhouse gas emissions and 50% of global waste. The circular economy is a paradigm that aims to promote the reduction, recycling, and repurposing of resource consumption. In doing so, it has a substantial impact on economic expansion, employment, and environmental quality [1]. Enhanced supply-side efficiency has substantially increased consumption while drastically reducing production expenses. All of these processes, nevertheless, have accelerated the depletion of scarce resources and imposed an ever-greater environmental burden. The United Nations Environment Programme estimates that between 7 and 10 billion tons of refuse are produced annually in cities [2]. This waste is generated by households, businesses, industries, and construction. When viewed from a more comprehensive standpoint, it becomes apparent that the Earth has entered a cycle of production and consumption that significantly exceeds its carrying capacity, resulting in the unsustainable utilization of resources. Long-term sustainability of the present state of affairs is unattainable; consequently, the swift execution of structural reforms in production and consumption mechanisms is essential. The "circular economy" is one of the concepts that has begun to garner attention in the midst of these difficulties. The concept of a circular economy (CE) emphasizes the effectiveness of material and energy fluxes.

In terms of the advancement of circular economy-aligned processes, the European Union (EU) is a leading supranational political and economic entity worldwide. Neoclassical economics, which prioritizes the efficient allocation of resources through the market, does not include a mechanism that accounts for the scarcity of natural resources. This economic methodology makes its underlying economic model (the linear economy) unsustainable in terms of the transportation of materials and energy by disregarding the finite characteristics of natural resources.

The circular economy employs two primary methodologies to address environmental issues. The initial objective is to enhance resource efficacy and decrease resource consumption, while the second is to produce sustainable products. The objective of this investigation is to investigate the literature's treatment of the circular economy in order to clarify the efficacy of circular economy practices and their correlation with eco-innovation initiatives in the European Union.

The objective of this article is to examine scholarly sources and studies in order to gain insight into the efficacy of circular economy activities and the factors that are propelling the EU toward a circular economy. The goal is to substantiate the action plan of eco-innovations and sustainable development within the context of the circular economy.

The issues of sustainable development, global warning, and climate change are becoming more prominent in the minds of nations. Scientific research underscores the necessity for organizations to adapt to global trends and to attempt to analyze and evaluate the factors that influence their performance in the direction of a circular economy. It was determined that the organization's performance in the direction of a circular economy is challenging to assess as a result of fragmented scientific research, as evidenced by the analysis of the scientific literature. The absence of instruments for evaluating the impact of eco-innovation on the implementation of the circular economy can restrict the opportunities of organizations to evaluate the situation regarding eco-innovations and to identify areas of activity that require improvement.

Systematic, comparative, content analysis, grouping, comparison, SALSA, and TOPSIS methods for scientific literature analysis are used in this study.

Limitations: Despite the fact that research was conducted in all EU countries, ranking them by optimal and weakest performance at the household level, certain limitations have been identified. As a result, the results may not be wholly generalizable to specific industries, which have more favorable conditions for implementing eco-innovations in accordance with the principle that nothing should be lost in nature. Further research should be conducted on eco-innovations that generate innovative concepts, procedures, and products that facilitate a reduction in ecological damage.

2. Conceptual Framework and Methodology

The literature evaluation that was already in place provided an opportunity to succinctly summarize and illustrate the effects of circular economy practices. Nevertheless, the majority of the research is centered on the interconnection among the circular economy, sustainable development, and eco-innovation. A comprehensive overview of the contribution of eco-innovation activities to circular economy practices is lacking. Scholars must have a more comprehensive understanding of the transition to a circular economy and the ability to adapt strategies to facilitate this process while considering all relevant stakeholders. The current research objective is to resolve and contribute to the following areas:

(1) In the European Union, what is the efficacy of circular economy practices?
(2) Which eco-innovation trends are propelling the European Union toward a circular economy?

In order to answer the research questions and reach our conclusions, an evaluation of numerous scientific sources and reviewed studies on the circular economy, its practices, and eco-innovation activities was conducted. An exploratory study was undertaken to examine the relationship between circular economy practices in the European Union and eco-innovation activities. The qualitative analysis pertaining to eco-innovation activities and circular economy practices has been concluded.

The analysis of secondary data enriches the current body of literature by offering the following insights: a thorough examination of the circular economy; an evaluation of the practices and eco-innovation initiatives within the European Union; strategies for sustainable development in the European Union; current developments and trends in the circular economy.

The current systematic literature review is conducted using the "SALSA method", which commences with a scoping search, progresses to an evaluation, and culminates in synthesis and analysis. Its aim was to demonstrate the European Union's defining circular economy practices and eco-innovation activities. Figure 1 illustrates the scoping investigation's objective.

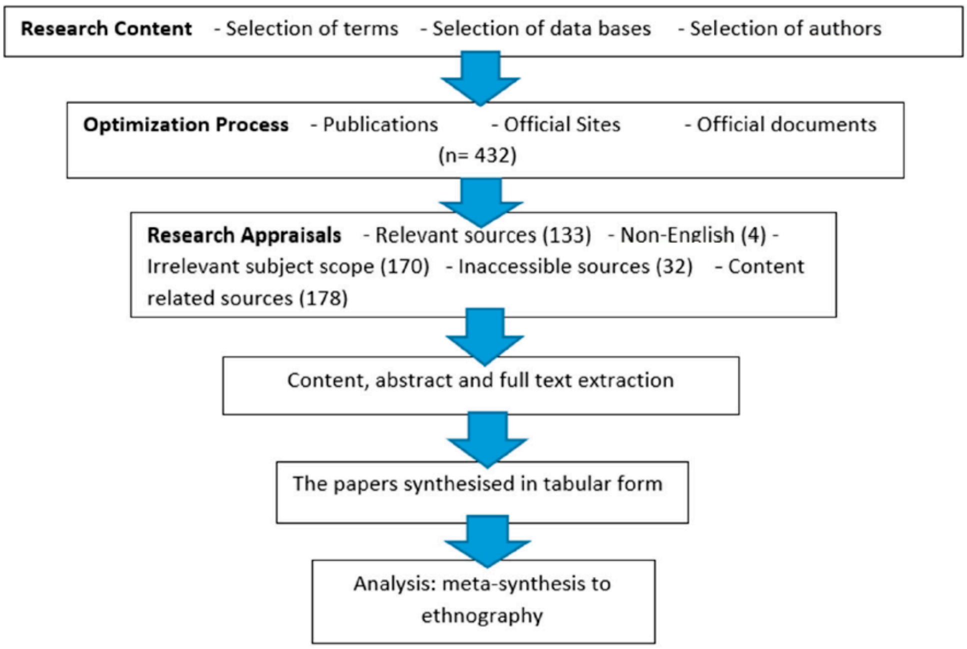

Figure 1. The process of the systematic literature review (developed by the authors).

The assessment procedure begins with the identification of pertinent sources and the exclusion of publications on the grounds of language barriers, content appraisal, and scope. The selected publications were centered on subjects that were pertinent to the objectives of the research. The significance of every publication was determined by examining its abstract, body, and coherence within the text. To ensure rigorous selection for synthesis and analysis, publications were excluded subsequent to a thorough examination of their complete texts. The results were compiled and presented in a tabular format following a comprehensive review of the pertinent literature. The investigation encompassed the primary determinants that influence circular economy initiatives in the European Union and their relationship with eco-innovation initiatives. Each study was contrasted and assessed in accordance with the ethnographic meta-synthesis procedures.

3. The Circular Economy and Its Practices in EU Conclusions

Following the Industrial Revolution and World War II, the capitalist economic system gained momentum and designed production and consumption processes using the pro-capital take–make–waste linear economic model. Nevertheless, as the environmental repercussions of an unrestrained pursuit of development and progress became evident in tandem with the execution of economic strategies, debates arose regarding the most sustainable way to achieve economic growth and progress while taking environmental considerations into account.

In an endeavor to resolve sustainable development concerns and bridge the development gap, a variety of conceptual frameworks have been proposed [3]. The circular economy model, which is based on a closed-loop system that includes reuse, re-sharing, repair, refurbishment, remanufacturing, and recycling, is not distinct from the capitalist system. Nevertheless, it is intended to confront resource-related obstacles that impede development by considering environmental factors, in contrast to the linear economy. This methodology is founded on two fundamental tenets: the first is the reutilization of resources from what are considered waste, and the second is that economic expansion can be achieved independently from the depletion of natural resources [4]. The circular economy is an economic framework that prioritizes business models that transform the production system by eliminating the concept of end-of-life. The fact that the term is employed differently by various stakeholders appears to be the cause of fundamental variations in circular economy definitions. The definition of the circular economy is subject to change based on the preferences of different stakeholder groups, as the concept is frequently referred to as "sustainability" in the contemporary era.

The concept is frequently interpreted as a functionalization strategy for enterprises that are involved in the implementation of sustainable development initiatives. However, it has also been criticized for its lack of practicality, particularly in the context of environmental welfare and in relation to other concepts, such as green economy or green development [5]. Since the early 1950s, literary works have employed terms, such as "Reproduction", "Reverse Logistics", and "Renewal", to delineate the concept. Nevertheless, the term "Circular Approaches" has become the standard in academic literature since 1984 [6]. The CE aims to achieve a competitive advantage by optimizing resource utilization. Resource efficacy is enhanced by adhering to the "Reduce, Reuse, Recycle" (3R) principles. The 3R principles consist of a reduction in resource consumption, the promotion of resource reuse, and the recycling of byproducts [7].

The Ellen MacArthur Foundation [8] defines the CE as a fundamental shift in the way in which human society interacts with the natural world. Its objectives are to promote sustainable development, avert resource depletion, and conclude energy and material cycles. The CE is a critical concept that emerged in the early 1990s and promotes the integration of principles for external effects into the economy. It also alludes to the actual function of the environment.

The circular economy aims to implement a paradigm shift in both production and consumption, promoting models that are low in carbon emissions and metabolism. Undoubtedly, the circular economy's economic, environmental, and social benefits have a profound impact on the political existence of contemporary societies [9]. Consequently, there is a significant amount of anticipation surrounding the concept of the circular economy. The generation of new business opportunities, a reduction in material expenditure, the mitigation of price volatility, the enhancement of supply security, and the minimization of environmental repercussions are among the many expectations. It is expected that it will ultimately act as a catalyst for economic growth [10]. Regional variations in this forward-thinking progress are inevitable [11].

Moreover, the circular economy is predicated on the practice of recycling products at the conclusion of their life cycle following their long-term utilization. Preserving and enhancing natural capital through the resolution of systemic and resource challenges, optimizing resource efficiency, and sustaining system efficacy are the three pillars upon which this strategy is built [12]. The adoption of a "take-use" approach to production and consumption has occurred with the emergence of industrial society.

The aforementioned strategy has resulted in a significant disparity between the demand for materials and the availability of resources, which has significantly slowed the rate of natural renewal [13]. Conventional economic development methods are significantly associated with environmental degradation and refuse production [14]. As a consequence, the circular nature of the future is now a significant focus of the fundamental approach. Additionally, this fundamental principle is embraced by European resource efficiency [15]. In its 2015 report, "Closing the Loop—An EU Action Plan for the Circular Economy," the European Commission offers a definition of circular economy that prioritizes the conservation of economic resources and a reduction in waste production. The European Union's endeavors to establish a resource-efficient, sustainable, low-carbon, and economically competitive system are regarded as being anchored by the establishment of a circular economy. By implementing a circular economy, which enables the recycling of depleted resources, Europe can establish a sustainable competitive advantage—a technological revolution, if you will [15]. The "Circular Economy Action Plan" was unveiled by the European Commission in December 2015.

The action plan comprises amended legal recommendations pertaining to refuse. The plan encompasses a comprehensive range of metrics that pertain to each phase of a product's life cycle, including production, consumption, waste management, and the secondary raw materials market. Furthermore, Ref [16] introduced a series of action plans aimed at enhancing circularity in investment and innovation. These plans encompass particular sectors, such as construction and demolition, bio-based products, plastics, food waste, and critical raw materials. In addition to the anticipated increase in resource efficacy, this is expected to result in a 17–24% reduction in material requirements by 2030. In the European Union, Germany has been a pioneer in the development of waste management legislation. The challenge of insufficient landfill capacity for waste, which led to logistical complications, was the primary catalyst for Germany's progress in efficient waste management during the 1980s [17]. By the conclusion of the 1980s, waste collection sites in Germany were not only unmanageable but also uncontrollable at the current rate. Furthermore, the number of waste incineration facilities was quite limited. At first, the primary focus was on improving the sanitation of incineration facilities and guaranteeing the safety of waste disposal sites. In an endeavor to mitigate the emissions of incineration facilities, rigorous regulations were implemented. Significant resources have been allocated to the dispersal of refuse by both municipal and private entities. Over time, it became evident that refuse disposal alone was insufficient as a solution. The development of an efficient waste management model was hypothesized to be possible through the prioritization of waste avoidance, energy recovery, and waste recycling. In accordance with the "polluter pays" principle, refuse generators were held accountable for the procedure. This principle necessitated a heightened focus on waste prevention and development initiatives that are environmentally sustainable throughout the product manufacturing process. It was mandatory for manufacturers and product distributors to create designs for their products that minimized waste production and facilitated the retrieval and disposal of goods in an environmentally sustainable manner.

The principle of extended producer responsibility was first implemented in 1991 with the implementation of the Packaging Regulations. These required the collection of packaging components for recycling after the product was consumed. The percentage of residential refuse designated for recycling increased from approximately 15% of the 40 million tons of waste in 1990 to 60% of the 45 million tons of waste in 2004 and 65% of the 45 million tons of waste in 2010, as per SB (2012). The applicability of this principle was broadened by the Closed Substance Cycle and Waste Management Act of 1996. As a result of its renaming in 2012 as the Circular Economy Act, this legislation required the implementation of extended producer responsibility. In addition to voluntary commitments from producers and distributors, this was achieved through the implementation of legally binding measures. The Circular Economy Act was enacted in 2012. The most preferable waste hierarchy is waste prevention, followed by reuse, recycling, and other recovery techniques. It is composed of a five-step waste hierarchy. The final and least preferable stage is the disposal of the refuse in a landfill. The "polluter pays" principle is implemented in the field of refuse management. Consideration is given to the participation of stakeholders and the application of the most effective techniques available. Extended producer responsibility guarantees that the producer's accountability persists across the complete life cycle of the product, encompassing not only the sale but also the procurement of raw materials, manufacturing, distribution, utilization, and recycling/disposal of the product after it is no longer useful (Table 1).

Table 1. European Union Circular Economy Index.

	Household Waste (Per Person/Year)	Household Waste Recycle Rate	Domestic Waste Return Rate	Recycled Raw Material Usage Rate in Production	Material Reuse Rate	Number of Patents Related to Circular Economy (Since 2000)
Austria	~564 kg	~200 kg	~60%	~0.30%	~9%	~120
Belgium	~450 kg	~350 kg	~55%	~0.20%	~18%	~100
Bulgaria	~400 kg	~100 kg	~35%	~0.10%	~3%	~10
Cyprus	~650 kg	~330 kg	~18%	~0.12%	~3%	~5
Croatia	~400 kg	~90 kg	~20%	~0.25%	~5%	~5
Czech Republic	~340 kg	~80 kg	~35%	~0.25%	~7%	~70
Denmark	~780 kg	~145 kg	~50%	~0.30%	~10%	~55
Estonia	~375 kg	~261 kg	~30%	~0.25%	~10%	~3
Finland	~500 kg	~190 kg	~40%	~0.05%	~7%	~110
France	~510 kg	~135 kg	~40%	~0.25%	~20%	~540
Germany	~626 kg	~150 kg	~65%	~0.25%	~10%	~1260
Greece	~500 kg	~80 kg	~18%	~0.15%	~0.9%	~5
Hungary	~380 kg	~175 kg	~35%	~0.25%	~5%	~35
Ireland	~565 kg	~215 kg	~40%	~0.20%	~2%	~40
Italy	~500 kg	~180 kg	~45%	~0.20%	~20%	~295
Latvia	~415 kg	~111 kg	~25%	~0.20%	~3%	~10
Lithuania	~445 kg	~120 kg	~50%	~0.15%	~4%	~20
Luxembourg	~615 kg	~175 kg	~50%	~0.1%	~11%	~25
Malta	~620 kg	~75 kg	~7%	~0.12%	~11%	~1
Netherland	~520 kg	~540 kg	~55%	~0.18%	~29%	~170
Poland	~305 kg	~250 kg	~45%	~0.2%	~15%	~300
Portugal	~460 kg	~130 kg	~30%	~0.25%	~2%	~20
Romania	~260 kg	~75 kg	~15%	~0.15%	~2%	~35
Slovakia	~350 kg	~110 kg	~25%	~0.15%	~5%	~10
Slovenia	~465 kg	~70 kg	~60%	~0.40%	~8%	~8
Spain	~440 kg	~135 kg	~30%	~0.20%	~9%	~211
Sweden	~445 kg	~210 kg	~50%	~0.20%	~7%	~50

Source: www.politico.eu, accessed on 20 May 2024 (prepared by the authors).

Germany's recycling rate approaches 65%, while its refuse disposal rate is 5%. The remaining 30% is classified as refuse energy recovery. The European Union anticipates that its Member States will have implemented a recycling rate of 75% for packaging refuse and 65% for municipal waste by 2030 [18]. Germany has already exceeded these objectives, in addition to Slovenia, Austria, Belgium, and the Netherlands. Malta, Greece, Cyprus, and Romania, in contrast, are significantly behind these objectives [19].

An additional investigation that examined the implementation of circular economies in the European Union employed indicators, such as waste management, resource efficiency, employment in environmental protection, and renewable energy utilization, to estimate the circular economy model [20]. Research findings from 2008 to 2017 indicate that material use, or resource utilization efficacy, is the most significant indicator of the circular economy. Denmark, the Netherlands, Luxembourg, Italy, and Spain are the European Union Member States that demonstrate the highest levels of resource efficacy. The labor force that is involved in the manufacturing process of environmentally responsible products is an additional factor that influences the circular economy [21]. Sweden, Denmark, and Finland are the nations that are at the forefront of this issue. Additionally, Sweden, Hungary, and Slovakia are highly regarded as contributors to the circular economy in terms of refuse management. In addition to the aforementioned components, the circular economy is dependent on the presence of businesses that specialize in environmentally beneficial products. Lithuania, Portugal, and Austria are noteworthy in this regard.

Sweden, Denmark, and Latvia are the nations with the highest proportion of renewable energy in their energy consumption containers. Ref. [22] conducted a revision of the research conducted by [23] to examine the impact of the adoption of a circular economy on the performance of enterprises in 28 EU countries. The transition to a circular economy was categorized into distinct phases in the aforementioned study. Individuals who intend to transition to the circular economy, potential adopters, adopters, and non-adopters comprise the four distinct categories. The study's results indicated that the efficacy of those who have implemented the circular economy is superior to that of those who are in the process of adopting it and those who are inherently non-adopters. Nevertheless, the efficiency of those who are thinking about adopting the circular economy is not greater than that of those who have not yet done so.

Germany is another nation that has implemented the circular economy concept on an international scale. The primary impetus for Germany to establish an efficient waste management policy was the insufficient landfill capacity for waste disposal in the 1980s [24]. Refs. [25,26] underscore the three critical components of the circular economy: economic benefits, resources, and the environment. The findings indicate that the circular economy measures in EU Member States are exceedingly diverse. Significant factors that contribute to the clarification of this variability include the proportion of revenue allocated to research and development in 2015 and the scale of the firm. The aggregate variability in circular economy measurement data is comprised of 6.1% to 15.1% variability between nations. It is evident that the majority of framework policies implemented at the European Union level require meticulous preparation and execution, as the circular economy measurements concentrate on small and medium-sized enterprises (SMEs).

4. Eco-Innovation and Sustainable Development in EU toward Circular Economy

The notion of economic growth has been superseded in contemporary society by sustainable growth, which considers environmental sensitivity. Likewise, the notion of eco-innovation is supplanting the concept of innovation, which was once regarded as the bedrock of economic development and growth [27,28]. It is evident after a thorough examination that a production and consumption cycle exists that exceeds the Earth's carrying capacity, leading to the unsustainable depletion of resources. Swift structural transformations in production and consumption processes are an absolute necessity, as it is no longer practicable to sustain the current state of affairs for an extended period. The circular economy emphasizes the efficiency of energy and material flows and incorporates the ideas of eco-innovation and the principle that nothing should be lost in nature. Chen et al. [29] defined eco-innovation as the development of environmentally friendly processes and products, such as energy conservation, pollution prevention, refuse recycling, and eco-efficiency. According to Halila and Rundquist [30], eco-innovation encompasses developments that are designed to foster environmental sustainability. Eco-innovation is the development and implementation of innovative concepts, perspectives, commodities, and procedures that contribute to the realization of sustainable development objectives or mitigate ecological damage [31]. In order to elucidate the definition of eco-innovation, the Organization for Economic Cooperation and Development (OECD) incorporated two distinct characteristics. To begin with, eco-innovation refers to a form of innovation that places a primary focus on mitigating environmental impacts. Furthermore, it is important to note that eco-innovation encompasses not only advancements in organizational methods, processes, or products, but also social and structural innovations [32].

The European Union (EU) has been at the forefront of global initiatives promoting environmentally sustainable development and environmental consciousness since the 2000s. The growing international awareness and the initiatives of developed nations to decrease their reliance on natural resources have generated heightened curiosity regarding eco-innovations. As defined by the European Commission in 2001, eco-product innovation refers to advancements that reduce environmental risk, optimize resource utilization throughout the production process, and minimize refuse generation during disposal. In comparison to conventional products, eco-product innovation not only safeguards the natural environment but also offers greater environmental advantages [33]. Eco-innovation encompasses a wide range of environmentally sustainable processes and technologies, including waste reduction, green production and energy, and pollution control technology.

The European Union has made significant strides in the field of eco-innovation, as it has in all environmental-related domains. Since 2012, the European Union has employed an index to evaluate the eco-innovation levels of its Member States. This system allows the EU to monitor the advancements of its Member States in the field of eco-innovation, ascertain the effects of its policies, and assume the responsibility for the development of new policies. The Netherlands, Denmark, Finland, Luxembourg, Sweden, Austria, Spain, France, and Germany are all at the forefront of eco-innovation. In this study, panel unit root analysis will be employed to examine the proximity of other EU countries to the average of the foremost countries in eco-innovation. The European Union (EU) had a substantial impact on the preparation and establishment of objectives for the Paris Agreement, which was implemented in 2020 [34]. Additionally, the EU engages in substantial endeavors pertaining to sustainability and the environment by means of a variety of practices that have an impact both within and beyond the Union. Undoubtedly, one such initiative is the European Green Deal. The EU has established the objective of achieving climate neutrality by 2050 through the implementation of the European Green Deal [35]. The European Union (EU) is actively striving to enhance its endeavors in eco-innovation with the intention of realizing its continental climate neutrality objective, as outlined in the European Green Deal. Presently, numerous nations regard eco-innovation as a critical remedy for environmental challenges, including but not limited to climate change and energy security [36]. The European Union is in agreement regarding the criticality of innovation in attaining intelligent, sustainable, and inclusive expansion. As a consequence, the European Union initiated the Eco-Innovation Action Plan (EcoAP) as part of the 2020 Framework Programme [37]. Significant progress is being made by the EU in the area of eco-innovation. Since 2006, approximately 76% of businesses in EU Member States have been engaged in eco-innovation-related activities. A minimum of 10% of the innovation expenditures of over 57% of these companies have been designated to sustainable initiatives, such as energy efficiency, CO_2 emission reduction, pollutant minimization, and recyclability enhancement [38]. In addition, eco-innovation indicators serve to foster greater societal awareness regarding eco-innovation and motivate organizations to intensify their endeavors in this domain [32]. Using data derived from these sources, the EU, in conjunction with the International Organization for Standardization (ISO) and the Statistical Office of the European Union (EUROSTAT), monitors the level of eco-innovation in member countries at the national level.

The development of new eco-products or the improvement of existing ones are all part of eco-product innovation practices. Eco-product practices are designed to reduce the environmental impacts of a variety of products throughout their entire life cycle, as the primary environmental consequences are derived from their utilization (e.g., fuel consumption) or disposal (e.g., heavy metals in batteries) [39]. Eco-process innovation practices involve the improvement of existing production processes or the introduction of new processes in order to mitigate environmental impacts. During the production process, eco-process innovation incorporates a variety of initiatives, such as a reduction in waste and hazardous emissions, the recycling of waste for reuse, and more [30]. Consequently, the EU eco-innovation index utilizes sixteen indicators that are arranged in five dimensions to assess the extent of eco-innovation in Member States. According to Melece [25] the EU eco-innovation index incorporates the following dimensions: socioeconomic outcomes, resource efficiency, eco-innovation inputs, eco-innovation activities, and eco-innovation outputs. Countries are classified as eco-innovation leaders, middling eco-innovators, or countries catching up in eco-innovation according to the EU eco-innovation index scorecard [29]. The eco-innovation index rankings for EU Member States in 2022 indicate that Denmark achieved the highest score, while Bulgaria obtained the lowest. Upon examination, Denmark, Finland, Luxembourg, Sweden, Austria, Spain, France, Germany, and the Netherlands are deemed to be at the forefront of eco-innovation, according to the report. In terms of environmentally sustainable innovation, the countries of Portugal, Italy, the Czech Republic, Belgium, Ireland, Latvia, Estonia, Slovenia, and Greece are classified as average. Without a doubt, Denmark, Finland, Luxembourg, Sweden, and Austria occupy a unique and notable position when it comes to eco-innovation when compared to other nations. It is possible to assert that certain nations are exhibiting a convergence towards the mean value observed in the dominant nations. Under no circumstances can Estonia, Lithuania, Croatia, Italy, Latvia, Poland, Romania, Slovenia, and Greece converge to the average of the dominant nations. It is worth mentioning that with the exception of Italy and Greece, the countries that do not exhibit convergence became members of the Union in 2004 or later. Furthermore, it is puzzling that Greece, which joined the Union in 1981, and Italy, which was a founding member, are unable to converge towards the Union's leading nations in terms of eco-innovation. Additionally, it is worth noting that Bulgaria, which joined the organization in 2007, has the lowest eco-innovation score, indicating a trend toward parity with the average eco-innovation scores of the leading nations. This particular instance warrants a distinct analysis and assessment.

The achievement of the European Union's environmental objectives will be contingent upon the development of the remaining Member States that are unable to attain convergence in this domain. As the disparity between the leading countries and the remaining countries unable to attain convergence further expands, an unbalanced framework may develop within the Union, potentially impeding the attainment of environmental objectives. Hence, it is imperative to establish collaborative efforts and mechanisms to promote and facilitate advancements in eco-innovation for developing nations that are falling behind and who are unable to attain convergence.

5. Methodology

In multicriteria decision-making (MCDM), the optimal alternative is chosen from a limited number of options by evaluating a variety of criteria, many of which have competing objectives. The primary phases of multicriteria decision-making are as follows: define system assessment criteria that establish a clear relationship between the capabilities of the system and its objectives and develop alternative strategies to achieve the objectives (creating alternatives). Evaluate various alternatives according to specific criteria, employ one of the normative methods for conducting multiple criteria analysis, designate one alternative as the "optimal" or preferred choice, and, if the final answer is not chosen, gather additional information and advance to the subsequent phase of multiple criterion optimization. This study examines the TOPSIS approach, initially introduced by Hwang and Yoon in 1981 and then expanded upon by many writers, such as [40–43]. The abbreviation TOPSIS stands for technique for order preference by similarity to the ideal solution. Purchase decisions and outsourcing provider selection, manufacturing decision-making, financial performance analysis, service quality assessment, educational selection applications, technology selection, and material selection are among the numerous applications of TOPSIS. The TOPSIS approach is equivalent to the Hellwig taxonomy method for arranging items [44]. The primary benefits of this approach include the following [45]: it is a straightforward, logical, and easily understandable concept, offers intuitive and transparent reasoning that reflects human decision-making, provides a simplicity of calculation and strong computational effectiveness, has a scalar value that incorporates the ability to quantify the relative performance of each alternative, taking into consideration both the best and worst alternatives, in a concise mathematical format, and offers the potential for visual representation.

The TOPSIS method typically commences with the development of a decision matrix that denotes the satisfaction value of each criterion for each choice. The matrix is subsequently subjected to normalization using a predetermined normalizing technique, and the resulting values are subsequently multiplied by the weights designated to the criterion. Subsequently, the distance between each option and the positive ideal and negative ideal solutions is determined through the application of a distance measure. Ultimately, the alternatives are assessed and ranked in reference to their proximity to the optimal solution.

The Steps of the TOPSIS method:

STEP 1: Normalize the decision matrix.

The following formula can be used to normalize the decision matrix:

$$r_{ij}(\mathrm{x}) = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} i = 1, \ldots, m;\ j = 1, \ldots, n$$

STEP 2: Calculate the weighted normalized decision matrix.

This process converts different attribute dimensions into non-dimensional characteristics, enabling comparisons across criteria. In order to account for the different units of measurement used for various criteria, it is necessary to convert the scores in the evaluation matrix X to a standardized scale. Values can be normalized using one of many established standardized formulas. The following methods are often used to calculate the normalized value ij v.

According to the following formula, the normalized matrix is multiplied by the weight of the criteria:

$$v_{ij}(\mathrm{x}) = w_j r_{ij}(x) i = 1, \ldots, m;\ j = 1, \ldots, n$$

STEP 3: Determine the positive ideal and negative ideal solutions.

The aim of the TOPSIS method is to calculate the degree of distance of each alternative from positive and negative ideals. Therefore, in this step, the positive and negative ideal solutions are determined according to the following formulas:

$$A^+ = \left(v_1^+, v_2^+, \ldots, v_n^+\right)$$

$$A^- = \left(v_1^-, v_2^-, \ldots, v_n^{-+}\right)$$

So that the following is true:

$$v_j^+ = \left\{ \left(max\ v_{ij}(x) \middle| j\epsilon j_1\right), \left(min\ v_{ij}(x) \middle| j\epsilon j_2\right) \right\}\ i = 1, \ldots, m$$

$$v_j^- = \left\{ \left(min\ v_{ij}(x) \middle| j\epsilon j_1\right), \left(max\ v_{ij}(x) \middle| j\epsilon j_2\right) \right\}\ i = 1, \ldots, m$$

where j_1 and j_2 denote the negative and positive criteria, respectively.

STEP 4: Determine the distance from the positive and negative ideal solutions.

The TOPSIS method ranks each alternative based on the relative closeness degree to the positive ideal and distance from the negative ideal. Therefore, in this step, the calculation of the distances between each alternative and the positive and negative ideal solutions is obtained by using the following formulas:

$$d_i^+ = \sqrt{\sum_{j=1}^{n} \left[v_{ij}(x) - v_j^+(x) \right]^2},\ i = 1, \ldots, m$$

$$d_i^- = \sqrt{\sum_{j=1}^{n} \left[v_{ij}(x) - v_j^-(x) \right]^2},\ i = 1, \ldots, m$$

STEP 5: Calculate the relative closeness degree of alternatives to the ideal solution.

In this step, the relative closeness degree of each alternative to the ideal solution is obtained by the following formula. If the relative closeness degree has value near to 1, it means that the alternative has a shorter distance from the positive ideal solution and a longer distance from the negative ideal solution.

$$C_i = \frac{d_i^-}{\left(d_i^+ + d_i^-\right)},\ i = 1, \ldots, m$$

The TOPSIS approach is advantageous for decisionmakers in the organization of issues, the analysis of data, the comparison of potential solutions, and the evaluation of these solutions. The conventional TOPSIS technique is applicable to issues where all decision data are available and represented by precise numerical values. Nevertheless, the majority of real-world scenarios are characterized by a more complex structure. Several variations of the original TOPSIS technique have been proposed, which utilize interval or fuzzy criteria and weights to address imprecision, uncertainty, lack of information, or ambiguity. This article offers an explanation of the conventional TOPSIS algorithms for both interval and crisp data. Interval analysis is a simple and apparent approach to integrating data uncertainty into complex decision-making problems, and it has a variety of practical applications. Additionally, an investigation is conducted regarding the application of the TOPSIS methodology in a group decision-making setting. This paper delineates the application of multicriteria group decision-making in both interval and crisp data contexts. Lastly, we examine instances in which language variables are employed to subjectively state criteria and their weights. Highlighting its practical applicability, the TOPSIS approach is recommended for estimating proposals in a buyer–seller exchange.

6. Research

TOPSIS, as one of the MCDM methods, considers both the distance of each alternative from the positive ideal and the distance of each alternative from the negative ideal point. In other words, the best alternative should have the shortest distance from the positive ideal solution (PIS) and the longest distance from the negative ideal.

In this study there are 6 criteria and 27 alternatives that are ranked based on the TOPSIS method. Table 2 describes the criteria.

Table 2. Characteristics of criteria.

	Name	Type	Weight
1	Household waste (per person/year)	–	0.167
2	Household waste recycle rate	+	0.167
3	Domestic waste return rate	+	0.167
4	Recycled raw material usage rate in production	+	0.167
5	Material reuse rate	+	0.167
6	Number of patents related to circular economy (Since 2000)	+	0.167

Table 3 shows the decision matrix.

Table 3. Decision matrix.

	Household Waste (Per Person/Year)	Household Waste Recycle Rate	Domestic Waste Return Rate	Recycled Raw Material Usage Rate in Production	Material Reuse Rate	Number of Patents Related to Circular Economy (Since 2000)
Austria	564	200	60	0.3	9	120
Belgium	450	350	55	0.2	18	100
Bulgaria	400	100	35	0.1	3	10
Cyprus	650	330	18	0.12	3	5
Croatia	400	90	20	0.25	5	5
Czech Republic	340	80	35	0.25	7	70
Denmark	780	145	50	0.3	10	55
Estonia	375	261	30	0.25	10	3
Finland	500	190	40	0.05	7	110
France	510	135	40	0.25	20	540
Germany	626	150	65	0.25	10	1260
Greece	500	80	18	0.15	0.9	5
Hungary	380	175	35	0.25	5	35
Ireland	565	215	40	0.2	2	40
Italy	500	180	45	0.2	20	295
Latvia	415	111	25	0.2	3	10
Lithuania	445	120	50	0.15	4	20
Luxembourg	615	175	50	0.1	11	25
Malta	620	75	7	0.12	11	1
Netherland	520	540	55	0.18	29	170
Poland	305	250	45	0.2	15	300
Portugal	460	130	30	0.25	2	20
Romania	260	75	15	0.15	2	35
Slovakia	350	110	25	0.15	5	10
Slovenia	465	70	60	0.4	8	8
Spain	440	135	30	0.2	9	211
Sweden	445	210	50	0.2	7	50

The steps of the TOPSIS method:
STEP 1: Normalize the decision matrix.
The following formula can be used to normalize the decision matrix.

$$r_{ij}(x) = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} i = 1, \ldots, m;\ j = 1, \ldots, n$$

Table 4 shows the normalized matrix.

Table 4. The normalized matrix.

	Household Waste (Per Person/Year)	Household Waste Recycle Rate	Domestic Waste Return Rate	Recycled Raw Material Usage Rate in Production	Material Reuse Rate	Number of Patents Related to Circular Economy (Since 2000)
Austria	0.221	0.191	0.282	0.27	0.158	0.081
Belgium	0.177	0.334	0.258	0.18	0.316	0.068
Bulgaria	0.157	0.096	0.164	0.09	0.053	0.007
Cyprus	0.255	0.315	0.085	0.108	0.053	0.003
Croatia	0.157	0.086	0.094	0.225	0.088	0.003

Table 4. *Cont.*

	Household Waste (Per Person/Year)	Household Waste Recycle Rate	Domestic Waste Return Rate	Recycled Raw Material Usage Rate in Production	Material Reuse Rate	Number of Patents Related to Circular Economy (Since 2000)
Czech Republic	0.133	0.076	0.164	0.225	0.123	0.047
Denmark	0.306	0.138	0.235	0.27	0.176	0.037
Estonia	0.147	0.249	0.141	0.225	0.176	0.002
Finland	0.196	0.181	0.188	0.045	0.123	0.074
France	0.2	0.129	0.188	0.225	0.352	0.366
Germany	0.246	0.143	0.305	0.225	0.176	0.853
Greece	0.196	0.076	0.085	0.135	0.016	0.003
Hungary	0.149	0.167	0.164	0.225	0.088	0.024
Ireland	0.222	0.205	0.188	0.18	0.035	0.027
Italy	0.196	0.172	0.211	0.18	0.352	0.2
Latvia	0.163	0.106	0.117	0.18	0.053	0.007
Lithuania	0.175	0.115	0.235	0.135	0.07	0.014
Luxembourg	0.241	0.167	0.235	0.09	0.193	0.017
Malta	0.243	0.072	0.033	0.108	0.193	0.001
Netherland	0.204	0.516	0.258	0.162	0.51	0.115
Poland	0.12	0.239	0.211	0.18	0.264	0.203
Portugal	0.18	0.124	0.141	0.225	0.035	0.014
Romania	0.102	0.072	0.07	0.135	0.035	0.024
Slovakia	0.137	0.105	0.117	0.135	0.088	0.007
Slovenia	0.182	0.067	0.282	0.36	0.141	0.005
Spain	0.173	0.129	0.141	0.18	0.158	0.143
Sweden	0.175	0.201	0.235	0.18	0.123	0.034
Austria	0.221	0.191	0.282	0.27	0.158	0.081
Belgium	0.177	0.334	0.258	0.18	0.316	0.068
Bulgaria	0.157	0.096	0.164	0.09	0.053	0.007
Cyprus	0.255	0.315	0.085	0.108	0.053	0.003
Croatia	0.157	0.086	0.094	0.225	0.088	0.003
Czech Republic	0.133	0.076	0.164	0.225	0.123	0.047
Denmark	0.306	0.138	0.235	0.27	0.176	0.037
Estonia	0.147	0.249	0.141	0.225	0.176	0.002
Finland	0.196	0.181	0.188	0.045	0.123	0.074
France	0.2	0.129	0.188	0.225	0.352	0.366
Germany	0.246	0.143	0.305	0.225	0.176	0.853
Greece	0.196	0.076	0.085	0.135	0.016	0.003
Hungary	0.149	0.167	0.164	0.225	0.088	0.024
Ireland	0.222	0.205	0.188	0.18	0.035	0.027
Italy	0.196	0.172	0.211	0.18	0.352	0.2
Latvia	0.163	0.106	0.117	0.18	0.053	0.007
Lithuania	0.175	0.115	0.235	0.135	0.07	0.014
Luxembourg	0.241	0.167	0.235	0.09	0.193	0.017
Malta	0.243	0.072	0.033	0.108	0.193	0.001
Netherland	0.204	0.516	0.258	0.162	0.51	0.115
Poland	0.12	0.239	0.211	0.18	0.264	0.203
Portugal	0.18	0.124	0.141	0.225	0.035	0.014
Romania	0.102	0.072	0.07	0.135	0.035	0.024
Slovakia	0.137	0.105	0.117	0.135	0.088	0.007
Slovenia	0.182	0.067	0.282	0.36	0.141	0.005
Spain	0.173	0.129	0.141	0.18	0.158	0.143
Sweden	0.175	0.201	0.235	0.18	0.123	0.034

STEP 2: Calculate the weighted normalized decision matrix.

According to the following formula, the normalized matrix is multiplied by the weight of the criteria:

$$v_{ij}(\mathrm{x}) = w_j r_{ij}(x) i = 1, \ldots, m;\ j = 1, \ldots, n$$

Table 5 shows the weighted normalized decision matrix.

Table 5. The weighted normalized matrix.

	Household Waste (Per Person/Year)	Household Waste Recycle Rate	Domestic Waste Return Rate	Recycled Raw Material Usage Rate in Production	Material Reuse Rate	Number of Patents Related to Circular Economy (Since 2000)
Austria	0.037	0.032	0.047	0.045	0.026	0.014
Belgium	0.029	0.056	0.043	0.03	0.053	0.011
Bulgaria	0.026	0.016	0.027	0.015	0.009	0.001
Cyprus	0.043	0.053	0.014	0.018	0.009	0.001
Croatia	0.026	0.014	0.016	0.038	0.015	0.001
Czech Republic	0.022	0.013	0.027	0.038	0.021	0.008
Denmark	0.051	0.023	0.039	0.045	0.029	0.006
Estonia	0.025	0.042	0.024	0.038	0.029	0
Finland	0.033	0.03	0.031	0.008	0.021	0.012
France	0.033	0.022	0.031	0.038	0.059	0.061
Germany	0.041	0.024	0.051	0.038	0.029	0.142
Greece	0.033	0.013	0.014	0.023	0.003	0.001
Hungary	0.025	0.028	0.027	0.038	0.015	0.004
Ireland	0.037	0.034	0.031	0.03	0.006	0.005
Italy	0.033	0.029	0.035	0.03	0.059	0.033
Latvia	0.027	0.018	0.02	0.03	0.009	0.001
Lithuania	0.029	0.019	0.039	0.023	0.012	0.002
Luxembourg	0.04	0.028	0.039	0.015	0.032	0.003
Malta	0.041	0.012	0.005	0.018	0.032	0
Netherland	0.034	0.086	0.043	0.027	0.085	0.019
Poland	0.02	0.04	0.035	0.03	0.044	0.034
Portugal	0.03	0.021	0.024	0.038	0.006	0.002
Romania	0.017	0.012	0.012	0.023	0.006	0.004
Slovakia	0.023	0.018	0.02	0.023	0.015	0.001
Slovenia	0.03	0.011	0.047	0.06	0.023	0.001
Spain	0.029	0.022	0.024	0.03	0.026	0.024
Sweden	0.029	0.033	0.039	0.03	0.021	0.006

STEP 3: Determine the positive ideal and negative ideal solutions.

The aim of the TOPSIS method is to calculate the degree of distance of each alternative from positive and negative ideals. Therefore, in this step, the positive and negative ideal solutions are determined according to the following formulas:

$$A^+ = \left(v_1^+, v_2^+, \ldots, v_n^+\right)$$

$$A^- = \left(v_1^-, v_2^-, \ldots, v_n^{-+}\right)$$

So that the following is true:

$$v_j^+ = \left\{ \left(max\ v_{ij}(x) \middle| j\epsilon j_1\right), \left(min\ v_{ij}(x) \middle| j\epsilon j_2\right) \right\}\ i = 1, \ldots, m$$

$$v_j^- = \left\{ \left(min\ v_{ij}(x) \middle| j\epsilon j_1\right), \left(max\ v_{ij}(x) \middle| j\epsilon j_2\right) \right\}\ i = 1, \ldots, m$$

where j_1 and j_2 denote the negative and positive criteria, respectively.

Table 6 shows both positive and negative ideal values.

Table 6. The positive and negative ideal values.

	Positive Ideal	Negative Ideal
Household waste (per person/year)	0.017	0.051
Household waste recycle rate	0.086	0.011
Domestic waste return rate	0.051	0.005
Recycled raw material usage rate in production	0.06	0.008
Material reuse rate	0.085	0.003
Number of patents related to circular economy (since 2000)	0.142	0

STEP 4: Determine the distance from the positive and negative ideal solutions.

The TOPSIS method ranks each alternative based on the relative closeness degree to the positive ideal and the distance from the negative ideal. Therefore, in this step, the calculation of the distances between each alternative and the positive and negative ideal solutions is obtained by using the following formulas:

$$d_i^+ = \sqrt{\sum_{j=1}^{n} \left[v_{ij}(x) - v_j^+(x)\right]^2}, \; i = 1, \ldots, m$$

$$d_i^- = \sqrt{\sum_{j=1}^{n} \left[v_{ij}(x) - v_j^-(x)\right]^2}, \; i = 1, \ldots, m$$

Table 7 shows the distance to the positive and negative ideal solutions.

Table 7. Distance to positive and negative ideal points.

	Distance to Positive Ideal	Distance to Negative Ideal
Austria	0.154	0.067
Belgium	0.142	0.084
Bulgaria	0.183	0.035
Cyprus	0.176	0.045
Croatia	0.179	0.042
Czech Republic	0.17	0.051
Denmark	0.165	0.059
Estonia	0.163	0.06
Finland	0.166	0.043
France	0.113	0.094
Germany	0.09	0.156
Greece	0.188	0.025
Hungary	0.169	0.05
Ireland	0.172	0.044
Italy	0.132	0.079
Latvia	0.18	0.037
Lithuania	0.177	0.045
Luxembourg	0.168	0.05
Malta	0.182	0.033
Netherland	0.129	0.122
Poland	0.129	0.078
Portugal	0.178	0.042
Romania	0.184	0.038
Slovakia	0.179	0.037
Slovenia	0.172	0.073
Spain	0.153	0.051
Sweden	0.164	0.055

STEP 5: Calculate the relative closeness degree of alternatives to the ideal solution.

In this step, the relative closeness degree of each alternative to the ideal solution is obtained by the following formula. If the relative closeness degree has value near to 1, it means that the alternative has a shorter distance from the positive ideal solution and a longer distance from the negative ideal solution, as follows:

$$C_i = \frac{d_i^-}{\left(d_i^+ + d_i^-\right)}, i = 1, \ldots, m$$

Table 8 shows the relative closeness degree of each alternative to the ideal solution and its ranking.

Table 8. The ci value and ranking.

	Ci	Rank
Austria	0.304	7
Belgium	0.371	6
Bulgaria	0.161	24
Cyprus	0.204	17
Croatia	0.191	20
Czech Republic	0.231	13
Denmark	0.263	10
Estonia	0.268	9
Finland	0.206	16
France	0.455	3
Germany	0.634	1
Greece	0.119	26
Hungary	0.229	14
Ireland	0.204	17
Italy	0.376	4
Latvia	0.17	23
Lithuania	0.202	18
Luxembourg	0.228	15
Malta	0.155	25
Netherland	0.486	2
Poland	0.375	5
Portugal	0.192	19
Romania	0.171	22
Slovakia	0.173	21
Slovenia	0.298	8
Spain	0.249	12
Sweden	0.25	11

Figure 2 shows the C_i values.

The rankings of countries were derived by this study using the TOPSIS approach. The most optimal outcomes were achieved by the following nations: Germany secured the top position, followed by the Netherlands in second place, France in third place, Italy in fourth place, and Poland in fifth place. The nations with the poorest performance were as follows:

Greece ranked 26th, Malta ranked 25th, Bulgaria ranked 24th, Latvia ranked 23rd, and Romania ranked 22nd.

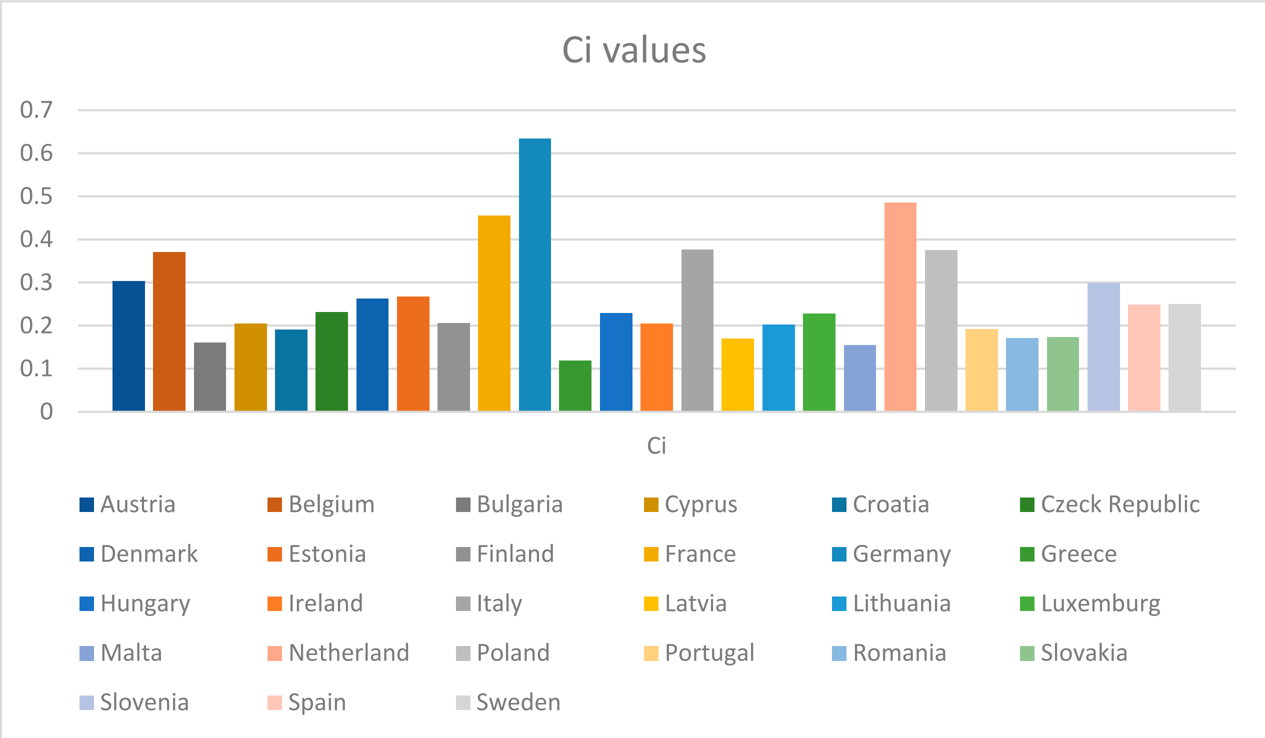

Figure 2. The C_i value.

7. Research Findings and Conclusions

Environmental concerns are becoming increasingly prevalent as a consequence of urbanization, industrialization, and accelerated population expansion. Subsequently, governments, multinational corporations, academics, and other stakeholders have participated in an extensive dialogue concerning environmental issues over the past three decades. The European Union (EU) is becoming a leader in the field of environmental objectives, both domestically and internationally. This is a tangible indication of the Green Deal's commitment to attaining climate neutrality. In order to achieve its objectives, the EU must unquestionably implement environmentally friendly technological advancements. Denmark, Finland, Luxembourg, Sweden, Austria, Spain, France, Germany, and the Netherlands have achieved significant progress in their eco-innovation initiatives, thereby establishing themselves as leaders among EU Member States. However, in order for the Union to effectively accomplish its predetermined objectives, it is essential that other nations establish a robust alliance with these preeminent powers. Greece, Poland, Estonia, Croatia, Hungary, Latvia, and Slovenia have all failed to achieve the same level of performance as the leading countries on average. It is important to note that the preponderance of these non-converging nations joined the Union in 2004 or later. It is perplexing that Italy and Greece, which were both founding members in 1981, have been unable to attain convergence with the dominant nations. Furthermore, Bulgaria, a member that first joined in 2007 with low levels of eco-innovation, may undergo further research and evaluation. However, it is currently demonstrating signs of approaching parity with the average performance of the leading nations. Italy distinguishes itself as the sole founding member of these non-converging nations that does not belong to the group of prominent nations.

The factors that contribute to the lack of convergence in nations that fail to demonstrate advancements in eco-innovation can be comprehensively examined. The development of the remaining non-convergent nations is essential for the EU to achieve its environmental objectives in a sustainable manner. Internal conflict within the Union may impede progress toward environmental objectives due to the growing disparity between these nations and the leading countries. Therefore, it is essential to create mechanisms that encourage collaborations and offer incentives to countries that are experiencing difficulties in attaining convergence in the field of eco-innovation and are falling behind. An analysis is also conducted to demonstrate the circular economy indicators of EU Member States in the form of data pertaining to their efficiency levels, including technical efficiency, overall efficiency, and inefficiency. The analysis determines the inputs and outputs that account for the efficiency scores of countries that are considered inefficient, the benchmark countries to which they are compared, and the efficient countries that they aspire to emulate.

In addition, the results of the analysis provide valuable insights into the extent to which less efficient nations can improve their inputs and outputs to achieve the same level of efficiency as the benchmark efficient nations. Belgium, Denmark, the Czech Republic, Ireland, Cyprus, Lithuania, Luxembourg, Austria, Romania, Slovenia, and Sweden are the nations with the highest circular economy performance. These findings are in accordance with the research conducted by [46]. In terms of efficacy, the following nations are ranked: Denmark, the Czech Republic, Romania, Lithuania, Belgium, Luxembourg, Sweden, Slovenia, Germany, Cyprus, Ireland, and Austria—all of which have achieved exceptional efficiency scores. Bulgaria, Malta, Croatia, Estonia, and Greece are the countries with the lowest efficacy, in order of decreasing performance.

Accordingly, we performed a multicriteria evaluation in TOPSIS to verify our documentary analysis and the results of other authors. Rankings of countries were determined based on TOPSIS method research. The results obtained by the TOPSIS method correlate with our documentary and other authors' analyses. The best results were from the following countries: Germany—1st place, Netherlands—2nd place, France—3rd place, Italy—4th place, Poland—5th place. The worst results were shown by the following countries: Greece—26th place, Malta—25th place, Bulgaria—24th place, Latvia—23rd place, and Romania—22nd place.

8. Conclusions

Sustainable growth has replaced the concept of economic growth in modern society, as it takes environmental sensitivity into account. Similarly, the concept of eco-innovation is rapidly replacing the notion of innovation, which was previously considered the foundation of economic development and growth [40]. It is evident upon a comprehensive examination that a production and consumption cycle exists that exceeds the Earth's carrying capacity, leading to the unsustainable depletion of resources. Swift structural transformations in production and consumption processes are an absolute necessity, as it is no longer practicable to sustain the current state of affairs for an extended period. The circular economy emphasizes the efficiency of energy and material fluxes, as well as the belief that nothing should be lost in nature and the concept of eco-innovation. Chen et al. [29] defined eco-innovation as the development of environmentally friendly processes and products, such as energy conservation, pollution prevention, refuse recycling, and eco-efficiency. ECO-INNOVATION, as defined by Halila and Rundquist [30], is a term that refers to advancements that are designed to enhance environmental sustainability. Eco-innovation is the development and implementation of innovative concepts, perspectives, commodities, and procedures that contribute to the realization of sustainable development objectives or mitigate ecological damage [39]. In order to elucidate the definition of eco-innovation, the Organization for Economic Cooperation and Development (OECD) incorporated two distinct characteristics in comparison to innovation. To begin, eco-innovation is a type of innovation that prioritizes a reduction in environmental effects. Additionally, it is crucial to recognize that eco-innovation encompasses not only improvements in organizational methods, processes, or products, but also social and structural innovations [32].The objective of this research was to examine the relationship between eco-innovation activities and circular economy practices in the European Union. The objective of the research is to examine scholarly sources and studies in order to gain a better understanding of the factors that are propelling the EU toward a circular economy and the efficacy of circular economy activities. We aimed to enhance the current corpus of research by conducting a comprehensive examination of the circular economy through the analysis of secondary data. The systematic literature review procedure involved the identification of pertinent sources, the subsequent rejection of articles based on predetermined criteria, and the compilation of the results for analysis. The research aimed to provide guidance for future research endeavors and to assist in the closure of the theoretical void in the academic literature regarding circular economy practices and eco-innovation activities.

After conducting research using the TOPSIS methodology, the rankings of countries were determined. The following nations obtained the most favorable results: Germany was the top-ranked nation, with the Netherlands in second place, France in third place, Italy in fourth place, and Poland in fifth place. Greece was ranked 26th, Malta was ranked 25th, Bulgaria was ranked 24th, Latvia was ranked 23rd, and Romania was ranked 22nd. These were the nations with the weakest performance. The TOPSIS method's results are consistent with the analyses of our work and other authors.

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