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Assessment of the Development of the Circular Economy in the EU Countries: Comparative Analysis by Multiple Criteria Methods

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Abstract

In recent decades, attention to environmental resource management has increased worldwide. Circular economy (CE) is a concept that is increasingly being considered as a solution to this range of challenges. Therefore, it is important to monitor the development of CE. This research is an attempt to contribute to the CE surveillance literature by providing a framework for comparing the positions of states and their classifications. The main goal of the article is to assess the level of circular economy development in EU countries according to the chosen methodology. The indicators used in this study are sourced from the European Commission Monitoring Framework database, which includes data from 27 European Union (EU) countries over the time frame from 2016 to 2020. The analysis was carried out using Multi-Criteria Decision Methods (MCDM), such as Simple Additive Weighing (SAW), and the objective method of estimating weights in accordance with proportional differences (APROD), which helped to assess the state of CE. The results showed that EU countries can be divided into three groups based on the level of performance of the CE, and their level of development in relation to the circular economy is different. The level of circular economy development in most EU countries is low. Germany, the Netherlands, France, and Italy demonstrated the best positions. The study findings were derived from the combination of two MCDMs, thus increasing the refinement of the overall methodology.

Keywords:

Circular Economy;
Assessment of Circular Economy;
Circular Economy Indicators;
Multiple Criteria Methods.

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1- Introduction

Aligned with the trajectory set by the Green Deal, the European Commission introduced a novel Circular Economy Action Plan in 2022, improving the previous plan implemented in 2015. This updated plan is designed to enhance the generation of product value through environmentally conscientious practices, improve waste reduction and recycling methodologies, and foster cohesive national and international efforts within the recycling economy. The document focuses on the textile, construction, electronics, and plastics sectors, which are using resources very intensively [1]. The EC Action Plan is supported and strengthened by various documents, such as packaging rules (2022), especially encouraging recycling and switching to biodegradable and compostable plastics [2]. Following the EU strategy, the Member States have developed national strategies for CE implementation. Of the 27 Member States, 16 countries have already published strategies, most of which are available on the European Circular Economy Stakeholder Platform website. The subsequent nations have disseminated their strategies for the Circular Economy: Belgium, the Czech Republic, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Poland, Portugal, Slovenia, Spain, and Sweden [3].

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The Circular Economy is grounded in three design-oriented principles: the utilization of waste and pollution, the optimal circulation of products and materials to attain their utmost value, and the restoration and renewing of natural systems. In practice, these principles are implemented based on various strategies: slowing down, closing, reducing, and restoring the flow of resources. The implementation of these strategies is complex and requires long-term efforts. During the process, it is important to ensure cooperation between the individual participants of the value chain, including the joint participation of consumers, producers, and service providers, the use of scientific potential, and the support of the public sector. Hence, the shift toward a circular economy model necessitates purposeful coordination and the instigation of systematic improvements, accounting for all components within the value chain and addressing all challenges [4]. The World Bank asserts that Europe is at the forefront of transitioning to a circular economy, underscoring the imperative for circular business models to transcend niche status and become mainstream [5]. For informed decision-making, process management, and evaluation of the efficacy of decisions, it is important to have the ability to quantifiably measure the phenomenon at the specified temporal juncture. In executing the circular economy action plan of nations and facilitating cross-country comparisons, it becomes pivotal to ascertain the present standing of a country concerning the advancement of the circular economy. At present, most countries report on the implementation of different indicators of the circular economy, but this information is of a comparative nature only, where different indicators in different countries are compared. Most countries only monitor indicators, but the current situation is not assessed in a comprehensive way, and the information provided does not make it possible to determine which country is in a better position with regard to the states of CE.

The CE assessment has been analyzed by international entities, domestic governments, scholars, and professionals. Nevertheless, the various aspects of the assessment process have been developed. The predominant focus of researchers lies in examining instances of CE assessment across various scales, encompassing evaluations of CE implementation at micro levels (individual companies or consumers), mezzo levels (eco-industrial parks), and macro levels (industry, city, province, region, and nation). At the academic level, the CE assessment issue has been divided into two broad directions: indicator selections at macro, mezzo, and micro levels and their combinations blocks [6–10] and methods used for comparative methedological issues discussions [11–15]. The discussion on indentifying aspects of CE assessment leads to the thematical indentification of particular impacts as conditional change, environmental pressure, and consumption [11–13, 16]. The comparative issue concentrates on testing the relationships among indicators [14, 15], grouping them in clusters [17], and developing particular indexes [18–20]. From our perspective, the main gap revealed through an examination of the current literature is the need for further refinement in the methodological approach when techniques are based on multicriteria methods. While that can be applied to assess circularity, this paper focuses on developing a novel approach based on MCDM to assess circular economy development at the national level, including all CE aspects.

The multidimensionality of a particular phenomenon makes it necessary to create composite indicators as a measurement method. Following Stanković et al. [18], we use modern multicriteria methods to provide the framework for tracking CE progress. Integration among the three measurement paradigms (macro, mezzo, and micro) requires additional future research too. Some causal indicators from mezzo- and micro-environments can reflect the real situation more deeply. This paper aims to compare the state of the CE in EU countries by employing some tools of multiple criteria analysis and to obtain the evaluation result in a convenient form that enables observing the situation in the region. This paper compares the state of the CE in EU countries by employing some tools of multiple criteria analysis and obtaining the evaluation result in a convenient form that enables observing the situation in the region. At this stage, the most popular MCDM SAW was chosen. The objective method of estimating weights in accordance with proportional differences (APROD) was used along with another accurate entropy method to increase precision. The results of the comparative evaluation will expand the assessment literature of the CE as well as to developers of the MCDM. The most challenging aspect of creating the index is to construct the methodological frame, capture, and unify the full line of every indicator's data for reliable comparison. The results of the comparative evaluation will be of interest to researchers in the CE as well as to developers of objective methods of estimating criteria weights.

2- Literature Review

To the best of our knowledge, the genesis of the concept can be traced back to 1976, when Walter Stahel collaborated with Genevieve Reday to articulate the notion of a 'circular economy' in a report titled 'The potential for replacing energy with work,' submitted to the European Commission. Nevertheless, this concept connects various intellectual frameworks, including but not limited to Performance Economy (1976), Industrial Ecology (1989), Biomimicry (1997), Cradle to Cradle proposed by McDonough and Braungart, which propels the transition from eco-efficiency to eco-effectiveness (2002), and the Blue Economy (2010) [21]. British researchers Pearce and Turner, who created the transition from “resources-products-pollution” to “regenerated resources-products-resources” model and proposed a closed cycle [22]. CE represents ‘an umbrella concept, integrating various scientific trends and practices aimed at sustainable resource management [23].

One of the most widely cited articles related to the emergency CE concept was written by Pearce in 1990, in which the author drew attention to the rapid degradation of nature as natural capital was rapidly transformed into industrial production and knowledge. The CE concept combines the knowledge of economics, environmental protection, and biology and derived knowledge from various areas. Brands of science emphasize highlight environmental protection as regenerative design, performance economy, blue economy, reverse logistics, natural capitalism, biomimicry, industrial ecology, permaculture, material passports, zero emissions, eco-efficiency and effectiveness, and resource efficiency [24]. The essence of the circular economy is a cycle covering all steps of the value chain where the perfect result will be achieved with the return of final products and waste to resources, as well as the elimination of pollution and regenerating nature. Although environmental issues are the most important, the social aspect as a mandatory prerequisite is often emphasized in the explanation of this concept. The capitalism system has been built on a linear production model for too long, and the movement to CE is stimulated by international and national governments as well as business leaders.

The paradigm of the CE is anticipated to revolutionize the interconnections between ecological and economic systems [25]. In their recent work, Alberich et al. [16] underscore the pivotal role of the bioeconomy concept within CE, wherein biological resources are intelligently managed, reclaimed, and repurposed to their fullest extent. Consequently, CE is integral to the overarching framework of sustainable development, wherein societal well-being forms an essential backdrop for processes that interlink economic and environmental facets. Kaplan [26] contends that the CE paradigm necessitates a shift from a currency-centric mindset to one rooted in nature, based on novel and appropriate economic behaviors. Such behaviors are envisioned not only to engender increased wealth and economic advancement but also to provide them with lasting sustainability. Lindgreen et al. [27] accentuate that CE should encompass the closure resource cycles, exemplified by the 9R paradigm: Reject, Rethink, Reduce, Reuse, Repair, Renew, Reprocess, Reuse, Recycle, and Recover Energy. This framework should create a positive influence on both the environment and economic growth. Conceptualized as an industrial economic system, the circular economy centers on the regeneration and recuperation of resources, with the objective of optimizing their utilization and extracting maximal value from products [28]. It represents an economic model that supplants the notion of "end of life" with strategies such as reduction, alternative reuse, recycling, and material recovery in the processes of production, distribution, and consumption. Operating at micro (products, companies, consumers), mezzo (eco-industrial parks), and macro (city, region, nation) levels, the circular economy aspires to attain sustainable development, concurrently fostering environmental quality, economic viability, prosperity, and social justice for present and future generations. This aspiration is achievable through innovative business models and conscientious consumer behavior. This definition is advocated as it aligns with the waste hierarchy while integrating the CE concept with the overarching goal of sustainable development [29]. Over the years, diverse definitions and interpretations of the CE concept have surfaced, categorizing it as a strategy, a novel economic paradigm, an industrial model, an economic system, an economic system for a new business, and a development model [17]. This article defines the conceptualization of the CE as an integral construct element of the green economy, seeking to establish an economic framework with negligible environmental impact.

This necessitates a paradigm shift in the utilization of diverse resources throughout production and consumption processes, with a pronounced emphasis on the abatement, reutilization, and recycling of component elements. The complexity of monitoring CE initiatives is a formidable challenge, primarily attributable to the absence of a standardized set of indicators or a universally accepted index. Moreover, the multiplicity of indicators rising from various interpretations of the CE concept further complicates the monitoring process among stakeholders. Certain European Union countries, such as France and the Netherlands, have devised their own indicator systems. Numerous environmental and resource-related indicators have been proffered by international organizations, including the Organization for Economic Co-operation and Development (OECD), which has put forth green growth indicators [30]. To facilitate a more coherent assessment of progress, the European Commission (EC) has adopted a circular economy indicators monitoring framework [18]. This framework encompasses dimensions such as production and consumption, waste management, secondary raw materials, as well as considerations of competitiveness and innovation [2].

The rising interest in the CE has increased a proliferation of scholarly articles delving into its development across distinct hierarchical levels: macro, mezzo, and micro. At the macro level, investigations are directed towards enhancing public policies governing CE production and consumption, entailing structural adjustments within industries, societies, and the global or national economy. The mezzo-level analysis interfirm and network relationships, encompassing phenomena such as energy cascading, the sharing of local infrastructure, byproduct exchange, and waste recycling. The micro level is concerned with the examination of internal processes within firms and the implementation of CE principles. Noteworthy is the proposal by certain authors [8, 31] introducing a fourth level of circularity denoted as the nano level, pertinently addressing products, components, and materials, with the micro level focusing on the operational dynamics of companies and consumers. Corona et al. (2019) [6] grouped circularity metrics into two distinct categories: circularity indices, designed to assess the level of circularity within a system, and circularity assessment tools, focused on analyzing the impact of circular policies on the tenets of the circular economy. This classification can be further nuanced into CE assessment indicators and CE assessment frameworks. The former involves individual (or aggregated) assessments, while the latter comprises tools providing multiple assessment indicators tailored to specific case studies.

Kusumo et al.'s (2022) contribution centers on monitoring CE applications in developmental stages, offering a three-gropued framework for CE indicators. At the macro level, the authors introduced a comprehensive set of indicators, including material flow analysis, eco-innovation, an evaluation index system for EC indicator development, green growth indicators, chiconomics wastewater index, resource productivity indicator, quantitative assessment of economic and ecological aspects, ecological cost-benefit ratio, longevity indicator, recycling rate, and global resource indicator. Notably, the product-level circularity metric emerges as a valuable measurement tool at the mezzo level. The micro-level assessment, as proposed by Kusumo et al., incorporates seven indicators: recyclability benefit rate, eco-cost value ratio, longevity indicator, recycling index, global resource indicator, and the product-level circularity metric, emphasizing the significance of these metrics at the micro-level [32]. Cagno et al. [10] sought to integrate three concepts—Sustainable Development, Circular Economy, and Industrial Symbiosis - employing semi-structured interviews to formulate a framework of 53 indicators at the micro level. This endeavor contributes theoretically to discussions surrounding the interplay of these paradigms. Importantly, the paper indirectly underscores synergies through the identification of similar indicators across the three paradigms. Macroeconomic advancement is conventionally assessed through a set of descriptive, efficiency, and performance indicators [11–13]. Drawing inspiration from the precedent European Monitoring Framework for Resource Efficiency, the European Circular Economy Strategic Framework advocates for the evaluation of Circular Economy indicators across three distinct tiers.

Firstly, thematic indicators are employed to gauge systemic shifts toward CE, encompassing dimensions such as market dynamics, technological advancements, and societal changes. Secondly, a panel of assessment indicators is established to quantify macro-level environmental pressures, employing methodologies such as Material Flow Analysis. Lastly, a key performance indicator, exemplified by Gross Domestic Product divided by internal material consumption, is selected to offer a comprehensive measure. The monitoring system instituted by the European Environment Agency also follows this system. Thematic indicator clusters, often integral to monitoring frameworks, serve as a foundational element, facilitating policymakers in the assessment of Circular Economy system evolutions at the macro level. For instance, within the theme "Development of the CE market," the French government has introduced diverse indicators encompassing the number of industrial and territorial green projects, household expenditure on product repair and maintenance, jobs generated by CE activities, and the quantity of raw materials recycled in production processes. Numerous frameworks underscore the significance of innovation and technological progress as pivotal indicators of CE development, as appraised through metrics such as the number of patents pertaining to the recycling of secondary processes and materials [12]. At the macro level, innovative indicators proposed at the municipal, regional, and national scales integrate material consumption, waste generation, or impact in monetary terms. These efficiency indicators amalgamate traditional economic metrics with environmental science indicators, exemplified by metrics like "water consumption per GDP" or material flow indicators such as GDP in relation to domestic material intensity. However, the establishment of comprehensive monitoring frameworks operating at an integrated and macroscopic level, capable of measuring CE development across diverse strata, remains a formidable challenge.

Căutişanu et al. [14] have proposed an assessment framework for evaluating Circular Economy, comprising five distinct categories of indicators: resource efficiency, environmental aspects, and constituent components. Emphasizing the pivotal role of waste management, these indicators encompass environmental management considerations, economic development factors, and social aspects deemed essential for the seamless transition of the economy towards circular practices. In a related vein, Vranjanac et al. [15] have undertaken a modeling endeavor, employing six indicators, to analyze Circular Economy innovations and performances across 27 European Union countries. The investigation relies on data sourced from the Eurostat database, spanning the period from 2018 to 2021. The outcomes of the study revealed preeminent performance among specific countries across various CE indicators. Croatia emerged as a leader in terms of resource productivity, while Germany excelled in the municipal waste recycling rate indicator. Additionally, Germany, Belgium, Austria, and Slovenia demonstrated superior performance in the circular indicator measuring material utilization rates. Italy and Estonia exhibited notable achievements in private investment, job creation, and gross value added within the circular economy sectors, as indicated by the value added at factor cost as a percentage of the GDP. The Netherlands outperformed in associated patents, secondary raw materials and recycling indicators, and the recycling rate for all waste types, excluding the primary indicator for mineral waste. Analyzing the geographical distribution of CE innovations, it was observed that developed European Union (EU) countries, including Germany, Italy, France, the Netherlands, Luxembourg, and others, exhibited a higher share of innovation. Alberich et al. [16] delineated and scrutinized twelve extant macroeconomic indices crafted and instituted by governmental entities and international organizations, positing these as alternative conceptualizations of circularity. The authors contend that resource efficiency indicators, while predominantly concentrating on the technical enhancement of production and efficiency gauged in monetary metrics, exhibit limitations in providing a comprehensive perspective of the economy. Specifically, these indicators, according to the authors, tend to overlook potential rebound effects, thereby neglecting the inadvertent consequences that could undermine the environmental aspirations of the Circular Economy and amplify the overall ecological impact of the economic system.

Mazur-Wierzbicka [17] employed statistical cluster analysis to identify and categorize 28 European Union (EU) countries based on their progression towards a circular economy. The authors selected indicators from the Eurostat database, encompassing data from 28 EU member states spanning the years 2016, 2018, and 2020. Through statistical analyses and grade correspondence cluster analysis, the hierarchical cluster analysis revealed the existence of two discernible groups of countries. The first group comprises Belgium, the Netherlands, Denmark, Luxembourg, Austria, Germany, Spain, France, Italy, and the United Kingdom, while the remaining countries constitute the second group. In a related study, Stankovic et al. [18] employed multi-criteria methods to establish a framework for formulating the CE index, subsequently ranking European Union (EU) member states based on their CE performance over the period from 2016 to 2020. The authors scrutinized 11 indicators, categorized into four groups: production and consumption, waste management, secondary raw materials, and competitiveness and innovation. The ranking outcomes indicated that Germany exhibited the most advanced circular economy during the observational period, followed by the Netherlands, France, and Austria.

Candan & Toklu [20] conducted research utilizing data obtained from the European Commission's CE monitoring system, analyzing EU countries with information spanning the years 2014, 2016, and 2018. Their study underscores the significance of employing weights, which they determined through a fuzzy, simple multi-attribute assessment technique. These weights were subsequently utilized in ranking the countries using the Combinative Distance-Based Assessment method. According to their findings, the top five countries are identified as the Netherlands, Luxembourg, Belgium, France, and Germany. On a parallel note, Androniceanu et al. [19] utilized information derived from various databases, including Eurostat, the World Bank, and the European Environmental Protection Agency. The authors compiled a CE index for 25 European Union (EU) countries. The compilation involved 13 variables, and the researchers combined these components to calculate a composite index, weighting each component based on the percentage of variance attributed to them. The results indicate that Germany, Austria, Sweden, Denmark, and the Netherlands exhibit the highest values, while Poland, Cyprus, Slovakia, Greece, Bulgaria, Latvia, and Romania exhibit the lowest values. Additionally, the final values were transformed into a standardized scale ranging from 0 to 100 points, with Germany registering the highest value of 100 points and Romania registering the lowest value of 0 points.

The scholarly literature addressing Circular Economy assessment can be categorized into two principal groups: the first group purifies the pillars and refers to indicators of CE measurement [6–10], while the second encompasses diverse measurement techniques [11–15]. Circularity indices identified in the literature can be further classified into two subsets: CE measurement indices, which quantify the degree of circularity, and indices assessing the interrelationships among these circularity indicators.

Summarizing theoretical and practical literature yields key insights. Firstly, the CE concept is inherently expansive, covering insights from various scientific disciplines, particularly those associated with the bioeconomy, and it remains in a constant state of development. Secondly, due to the breadth and complexity of the CE concept, assessment processes are chalanging, covering diverse pillars. Commonly assessed dimensions include production, consumption, waste, and the pursuit of innovation related to sustainable development. Thirdly, the development of indices based on multicriteria methods involves a sensitive phase wherein the identification of criteria weights significantly influences assessment outcomes. Fourthly, comparative analyses of countries' CE states are mandatory for identifying the most influential and innovative nations, offering exemplary CE policies.

In addressing the assessment gap, the article posits that employing a multicriteria method, which determines criteria weights without necessarily relying on expert input, enhances comparison opportunities and serves as a valuable tool for monitoring the state of countries' Circular Economy.

3- Data and Methods

To solve this problem in a constantly changing environment and to reduce the complexity of the problems solved, it is possible to use the theory of systems, which allows complex phenomena, structures, or processes to be analyzed systematically, i.e., to evaluate the relationship between their components. In this case, it is necessary to deliberately change the states of the complex objects in question, i.e., to manage them effectively [33, 34]. Each system can be managed and targeted decisions made only after quantification of its current (actual) status. It is possible to do this by multicriteria methods of assessment, which by their very nature are universal and help to assess the phenomena in question, expressed in many indicators.

The development of a country's circular economy can be seen as a complex process, as many aspects need to be taken into account quantitatively. The assessment of such processes is complex and is therefore carried out at certain stages, from the description of the process itself to the determination of quantitative expression [35]. The development of the country's circular economy is characterized by many indicators. In order to combine them into one generalizing size, a certain consistency is required.

Figure 1 shows that the assessment of the development of a country's circular economy begins with the establishment of a list of indicators. There are no clear rules that make it clear why one indicator or the other is included or not included in the common list of indicators. Bielinskas [36] states that the most important indicators reflecting the phenomenon under consideration should be selected and should not exceed 15. However, there is also the view that, in most cases, the choice of indicators is determined taking into account which indicators have been used in previous studies, the availability of data on these indicators, and the accuracy of these data [37, 38]. Other authors emphasize the importance of selecting indicators that are quantifiable when forming a system of indicators [39, 40]. Tamosaitiene (2009) [41] recommends choosing those indicators for which there is publicly available data, that is, the known methodology for data collection.

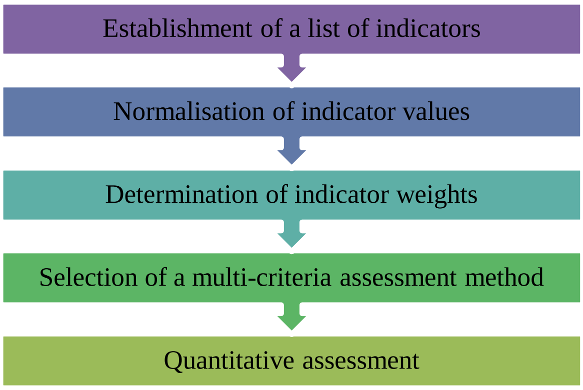

Figure 1. The scheme of assessment of country's circular economy development

The circular economy indicators of Eurostat were used for the research. A total of 21 indicators are available in the database, but only 11 indicators are included in the quantitative assessment (Figure 2). The reasons are explained in the results section.

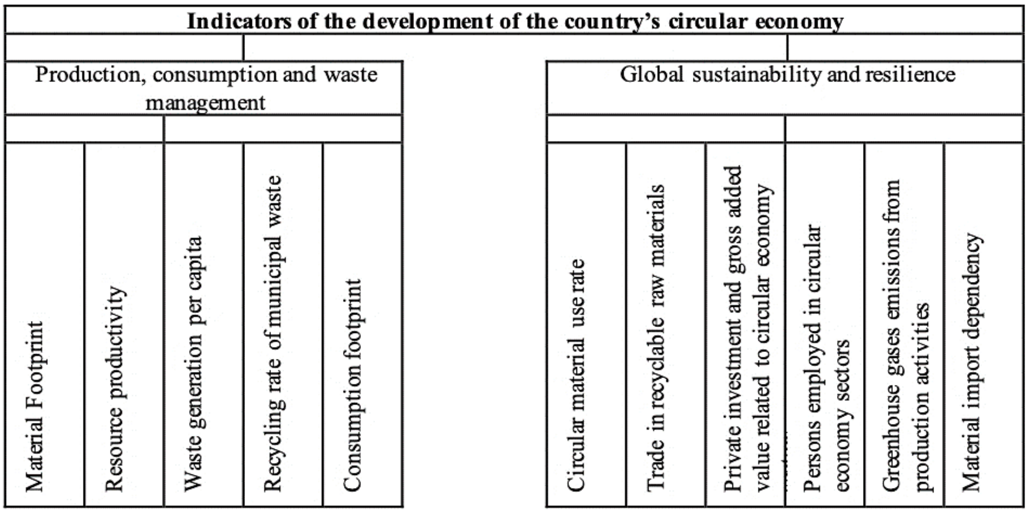

Figure 2. Hierarchical system of indicators for the development of the country's circular economy

The indicator system is divided into two subsystems: production, consumption, and waste management; and global sustainability and resilience. The improved values of these indicators signal an improved situation in the context of the circular economy. The circular economy aims to reduce resource consumption and optimize resource use. By minimizing waste and maximizing the value extracted from resources, it helps to conserve natural resources for future generations.

4- Results

The findings of the investigation indicate notable variances among European Union (EU) countries concerning their advancement toward a circular economy, as depicted in Figure 3. Evidently, discernible distinctions exist in the implementation of circularity, delineated from two distinct viewpoints. Firstly, there exists a discernible contrast in circular economy performance between the established and newer EU member states, with a predominance of the former occupying prominent positions in the ranking. Notably, the top three positions are secured by the founding EU countries: Germany, the Netherlands, and France. Secondly, a distinct dichotomy becomes apparent when comparing countries in Northern and Western Europe against those in Southern Europe. Part of the circular economy indicators presented in the Eurostat database, such as the generation of packaging waste per capita, was not included in the indicator system because the value of this indicator is integrated into another indicator. For example, such an indicator as waste generation per capita integrates all types of waste, making it inappropriate to single out plastic or other types of waste separately as it would duplicate values. Other indicators are also eliminated based on the same principle. However, other indicators have been eliminated due to a lack of data, e.g., many countries do not provide data on the food waste indicator, or this information is only available for one year, i.e., 2020.

After forming the system of indicators, we proceed to the normalization of the values of the indicators and the selection of a multicriteria evaluation method. Normalization of the indicator values was carried out according to the data presented in Appendix I ('Values of indicators').

Given the diverse dimensions in which indicators are expressed, the necessity arises to render them comparable for merging into a unified aggregate measure, typically achieved through normalization of indicator values. This process is essential for harmonizing disparate indicators and facilitating their integration, often accomplished through the application of multi-criteria methods. If the purpose of the quantitative assessment is to assess the status of the phenomenon in question taken separately, the normalized values of the indicators must be determined without context with the values of those indicators for other variants. Normalization is done in this way [42]:

$$\tilde{q}_{ij} = \frac{q_i}{q_i^{max}} \quad (1)$$

where $\tilde{q}_{ij}$ is normalised value for indicator i of variant j; q_i is value of indicator i of variant j; q_i^{max} is maximum possible value of indicator i.

Appendix II shows the normalized values of the criteria.

The APROD method has been chosen to determine the weights of the indicators. This functionality is used to combine normalized values with objective weights obtained from the newly proposed APROD method (Weights Corresponding to Proportional Differences) to derive weights from the data structure. This method of estimating weight is popular among scientists [43, 44]. Ginevi & Podvezko [35] describe that normalization (1) maps the values of each criterion to the interval [0,1], regardless of the difference between the values, whether they are close or distant to each other. The APROD method allows you to account for larger bias-transformed criterion values by assigning higher weights than the weights for smaller bias values. The relative differences between the extremes W*ᵢ* for each criterion *i* are measured as a percentage between the extremes, taking the base as the center, just as contrast is measured in optics.

$$W_i = 200 \times \frac{\max_j r_{ij} - \min_j r_{ij}}{\max_j r_{ij} + \min_j r_{ij}} \quad (2)$$

where W_i is the weight of the indicator i; r_{ij} is the indicator value, max r_{ij} is the highest indicator value; min r_{ij} is the lowest indicator value.

Then, having all these relative differences between extremes found, they are normalized to achieve the requirement that the sum of the weights equals unity by dividing each relative difference by the sum of all these differences, thus finding weights α_i:

$$a_i = \frac{W_i}{\sum_{i=1}^{n} W_i} \quad (3)$$

where a_i is the weight of the indicator i.

The weights of the indicators are shown in Table 1.

Table 1. Criteria weights

Criteria	Year	Material Footprint	Resource productivity	Waste generation per capita	Recycling rate of municipal waste	Circular material use rate	Trade in recyclable raw materials	Private investment and gross added value related to circular economy	Persons employed in circular economy sectors	Consumption footprint	Greenhouse gases emissions from production activities	Material import dependency
APROD weights	2016	0.070	0.101	0.109	0.080	0.106	0.119	0.119	0.119	0.012	0.068	0.096
	2018	0.077	0.099	0.108	0.084	0.106	0.117	0.117	0.117	0.019	0.064	0.093
	2020	0.077	0.057	0.107	0.088	0.112	0.123	0.123	0.123	0.022	0.068	0.101

The Simple Additive Weighting (SAW) method is widely used in social science research [42, 45]. This is the most well-known and widely used method in practice. It is popular because of its simplicity and ability to evaluate any complex phenomenon expressed in many indicators.

The values of the phenomenon in question are calculated according to the SAW method using the formula [46]:

$$K_p = \sum_{i=1}^{n} w_i q_{ij}^*, \quad (4)$$

where Kp is significance of multi-criteria evaluation by SAW method; wi is the weight of the i-th indicator, q_{ij}^* is the normalized value of the indicator.

The level of development of the circular economy of the EU countries was determined in the article. The data from the years 2016, 2018, and 2020 were analyzed. The data of these years was analyzed because part of the indicators is collected only every two years, and, therefore, in order to assess the phenomenon in question as comprehensively as possible, these indicators have not been eliminated, but the period under consideration has been chosen.

After setting the weights and applying the SAW method, the results of the multicriteria evaluation were obtained and are presented in Figure 3.

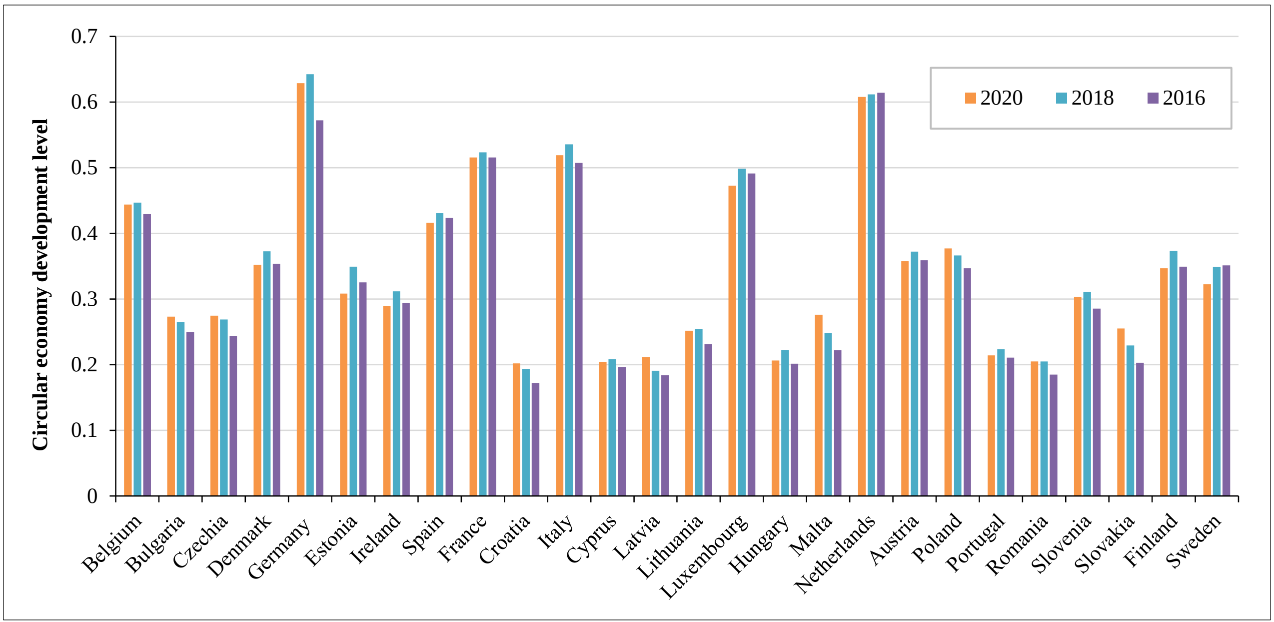

Figure 3. **The level of circular economy development in EU countries**

The value of the calculation is better if it is approaching 1. As we can see from Figure 3, Germany and the Netherlands retained the highest values during the period analyzed, so we can say that their circular economy level is in the best position compared to other countries. German (position 1) attained the best position. It thus can serve as a benchmark for all other countries, especially in criteria with the highest weights (which are assigned using the APROD method). In our case, the criteria with the highest weight are Trade in Recyclable Raw Materials, Private Investment, and Gross Added Value Related to CE, Persons Employed in the Sectors of CE, following slightly lower criteria such as Resource Productivity and Waste Generation per Capita (Table 1). In terms of such criteria, Germany attained the best relative position among the countries in the chosen period. The Netherlands is the next country in the resulting rating, and Italy and France proximally equally demonstrate the third position. Croatia, Cyprus, Latvia, Hungary, Romania, and Portugal are lagging in the proposed CE assessment index.

The results obtained were grouped into three groups: high, medium, and low levels of development of the circular economy (Figure 4).

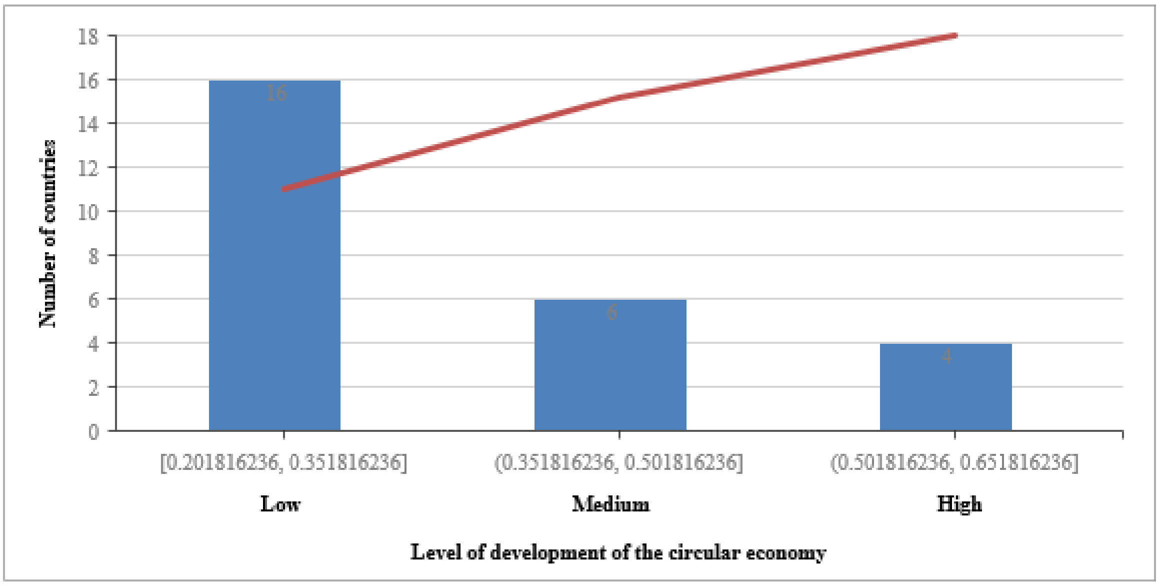

Figure 4. **Grouping of EU countries according to the achieved level of development of the circular economy**

Figure 4 shows that four countries (Germany, the Netherlands, France, and Italy) have reached the highest level of development of the circular economy. These countries have very good waste management results and a high number of people employed in circular economy sectors. The average values were attributed to Belgium, Denmark, Poland, Spain, Luxembourg, and Austria. The achieved level shows that private investments related to the circular economy sector are needed to improve the situation. Bulgaria, the Czech Republic, Ireland, Croatia, Cyprus, Latvia, Lithuania, Hungary, Malta, Estonia, Portugal, Romania, Slovenia, Slovakia, Finland, and Sweden have the lowest levels of development of the circular economy. The values of the indicators are low, which means that these countries have poor waste management, low use of recycled materials, a lack of private investment, high carbon emissions, etc. Thus, the results show that many EU countries have a low level of development of the circular economy, and therefore, in anticipation of better results, not only targeted policy-making but also investment is needed.

5- Discussion

The different levels of development are impacted by many social and economic factors. The level of implementation of national strategies, public awareness, environmental education, and the level of national and business investment in a transforming economy must be tracked more seriously. Future research should combine indicators of macro, mezzo, and micro environments to propose one index. Such integration of various measurement levels can more deeply reveal performance, highlighting causal relationships. Furthermore, prospective investigations into the progress of European Union (EU) countries in implementing CE principles could direct their attention towards the formulation of novel composite CE indicators, aiming to afford a more comprehensive depiction of the ongoing developments. This could extend to their application at both regional and municipal levels, enhancing the granularity of the analysis. Establishing a model for evaluating Circular Economy performance at the municipal or regional scale may serve as a valuable tool for decision-makers in the oversight and evaluation of environmental protection measures.

It is essential to acknowledge a constraint in the current research, specifically the unavailability of certain circular economy indicators, leading to incomplete data. Regarding indicators, the measurement of circular economy progress often relies on an array of sustainable development indicators, lacking specificity, particularly at the macroeconomic level. Another limitation involves the somewhat ambiguous distinction between sustainable economy and circular economy within the existing literature. The presented evaluation model has been verified by empirical research, the results of which may be helpful for scientists and practitioners (e.g., for Ministries of the Environment and Economy), analyzing the trends of the CE development of the countries or a particular region, and dealing with the problems.

Prospective avenues for research encompass an exploration into the evolution of CE indicators and their interrelation with indicators of sustainable development. Additionally, there is scope for applying diverse statistical methodologies to scrutinize these indicators in more detail.

6- Conclusions

The CE concept is the solution of careful usage of resources in reusing, recycling, and repairing in all aspects of human life by changing destructive production and consumption practices. The production and consumption loops must be closed to generate zero waste. During the past decade, many sets of indicators have been proposed by international organizations, national governments, scientists, and practitioners. Despite that, the assessment process is still in the development stage. Empirically, this study contributes to existing knowledge related to the measurement of the circular economy by offering a new approach using multicriteria methods to the assessment of circularity in the example of EU countries.

The results reveal that countries based on the development level of CE can be grouped into three clusters: high, medium, and low performance of CE. Germany, the Netherlands, France, and Italy demonstrate the highest scores, and Belgium, Denmark, Poland, Spain, Luxembourg, and Austria are at the medium level. Sixteen countries from Central, Eastern, and North Europe should improve their progress in CE. These results are partly in line with the article by Mazur-Wierzbicka [17], where the ranking was based on the principal component analysis method, and results showed that Luxembourg, Austria, Denmark, the Netherlands, and Belgium hold the highest positions in the ranking and Romania and Hungary the lowest. The main difference is that Poland, in our ranking system, demonstrates a middle position, while Mazur-Wierzbicka's article is the lowest. Also, our results demonstrate the same leaders (Germany, the Netherlands, France, and Italy) as in the article by Vranjanac et al. [15]. Our ranking positions for some countries are exactly the same as in the article by Androniceanu et al. - Germany and the Netherlands were fixed as leaders, and Bulgaria, Poland, Cyprus, and Romania were the lowest in the research [19]. The Netherlands, France, and Germany demonstrated the highest results in the research of Candan & Toklu too [20].

Some enough novel tools of the MCDA analysis were presented in the paper, continuing our previous study [47]. The new estimation method for weights, APROD, produces a rather rarely available opportunity to create weights without needing to address experts. The method gleans particularities of the data by conveying the relative variability between maximal and minimal values within the values. The paper provides a logical grounding for the named method to be used with the specific normalization of data in the SAW method, thus ensuring its prominence over other available methods. The enough novel approach of comparing results obtained by different MCDA methods was presented and used. It allows better comparison of results and normalized values. The methodology retains the complete flexibility of the SAW method and allows for broadening the set of criteria in further studies.

7- Declarations

7-1- Author Contributions

Conceptualization, D.G. and G.L.; methodology, M.S.; formal analysis, D.G.; resources, G.L. and D.G.; data curation, M.S.; writing—original draft preparation, D.G. and G.L.; writing—review and editing, M.S.; visualization, D.G.; project administration, D.G.; funding acquisition, D.G. All authors have read and agreed to the published version of the manuscript.

7-2- Data Availability Statement

Publicly available datasets were analyzed in this study. This data can be found here: https://ec.europa.eu/eurostat/en/web/main/data/database.

7-3- Funding

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7-4- Institutional Review Board Statement

Not applicable.

7-5- Informed Consent Statement

Not applicable.

7-6- Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

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Appendix I

Table A-1. Values of CE indicators

Country/ Criteria	Year	Material Footprint (Tonnes per capita)	Resource productivity (Euro per kilogram)	Waste generation per capita (Kilograms per capita)	Recycling rate of municipal waste (Percentage)	Consumption footprint (Index)	Circular material use rate (Percentage)	Trade in recyclable raw materials (Tonne)	Private investment and gross added value related to circular economy (Million euro)	Persons employed in circular economy sectors	Greenhouse gases emissions from production activities (Kilograms per capita)	Material import dependency (Percentage)
Belgium	2016	13.062	2.8933	5 573	53.5	103	17.6	1631874.19417	7 154	61 463	7772.56008	72.9
	2018	14.678	3.0398	5 967	54.4	104	19.9	1504426.23947	6 533	63 234	7824.34168	72.7
	2020	13.049	3.0819	5 899	51.4	106	21.5	1948777.75532	7 029	63 816	7070.8213	72.3
Bulgaria	2016	17.478	0.35	16 907	31.8	109	4.4	146 353.632	304	51 013	7862.37433	16.1
	2018	21.199	0.3488	18 470	31.5	112	2.5	160700.59535	394	52 418	7721.64319	15.7
	2020	20.671	0.3514	16 785	35.2	108	5.9	175057.54814	380	51 751	6691.6561	16
Czechia	2016	15.685	1.0542	2 402	33.6	100	7.5	63610.42677	598	120 738	10009.41263	32.3
	2018	16.807	1.1095	3 560	32.2	104	10.5	83630.16546	811	120 905	9859.44226	32.8
	2020	15.597	1.1559	3 598	40.5	100	11.6	66845.332	858	123 938	8380.75237	31.1
Denmark	2016	22.661	2.1046	3 663	48.3	110	8	1747918.21235	2 486	33 435	14111.38003	35.4
	2018	23.029	2.1214	3 702	49.9	110	8.1	1965786.88239	2 735	36 639	14398.67961	38.1
	2020	25.603	2.1457	3 45	45.0	109	7.5	1897572.17091	2 960	35 758	12086.46013	37
Germany	2016	15.744	2.4541	4 858	67.1	105	12.2	4668685.45468	2 486	677 723	9261.82501	40.1
	2018	15.961	2.5897	4 891	67.1	105	12.4	4307105.8475	2 735	744 774	8 90.89229	40.1
	2020	14.959	2.6908	4 824	70.3	104	12.9	3926042.05044	2960	764770	6996.2861	39.7
Estonia	2016	24.05	0.6313	18 451	27.9	106	11.6	27764.56607	132	11 644	14290.67622	22.5
	2018	30.321	0.5598	17 539	28.0	106	13.5	32 953.1707	195	13 829	14573.4494	23.7
	2020	27.87	0.6696	12 163	28.9	103	15.6	36852.16755	192	13 810	8052.88955	26.7
Ireland	2016	12.363	2.6609	3 207	40.7	103	1.7	1641486.48556	402	28 227	12965.01315	32.3
	2018	12.944	2.7679	2 874	37.7	106	1.6	2280015.54752	575	30 721	13449.43312	33
	2020	10.758	3.2605	3 248	40.8	94	1.7	1948448.41713	2 109	33 250	10261.00053	31.8
Spain	2016	9.62	2.7776	2 774	33.9	102	8.2	5386325.84788	5 008	405 105	5655.61386	42.9
	2018	11.016	2.627	2 945	34.8	106	9	5183096.53531	5 308	426 566	5808.48307	42.8
	2020	9.922	2.4586	2 230	40.5	97	9.3	5005185.31221	5 792	448 860	4592.49024	37.6
France	2016	12.639	3.0486	4 836	39.7	101	19.4	3630894.08126	20 257	470 463	5107.25563	39.1
	2018	13.844	2.9831	5 112	40.7	100	19.7	3747236.7174	18 397	518 745	4954.98632	37.9
	2020	10.901	3.0382	4 593	41.7	92	19.2	4019137.6309	20 108	521 357	4320.55081	36.2
Croatia	2016	12.465	1.1134	1 286	21.0	110	4.6	212146.19098	289	44 088	4472.29735	31
	2018	13.681	1.1688	1 355	25.3	115	5	298764.03638	409	51 368	4503.68157	31.4
	2020	13.085	1.0542	1 483	29.5	108	5.7	456310.13254	379	50 818	4441.64128	33.8

Italy	2016	10.923	3.4606	2 702	45.9	101	17.8	3651818.03292	8 310	612 645	5534.40536	48.9
	2018	11.597	3.5269	2 855	49.8	106	18.8	3748682.14734	12 803	585 644	5477.48111	50.6
	2020	9.846	3.4284	2 942	51.4	100	20.6	3399183.14669	12 070	617 149	4928.92649	46.5
Cyprus	2016	18.23	1.4369	2 897	16.1	104	2.4	120593.7353	58	6 840	8063.54499	33.6
	2018	20.181	1.3594	2 646	16.7	108	2.8	129647.22146	92	8 291	8295.04446	34
	2020	21.979	1.3256	2 491	16.6	100	3.7	159645.08576	50	8 348	7628.58739	32.4
Latvia	2016	14.355	1.0952	975	25.2	99	6.5	153176.78046	124	23 624	5137.89539	32
	2018	17.518	0.9647	920	25.2	96	4.7	193775.37745	241	22 420	5539.40218	32.9
	2020	18.04	0.9613	1 501	39.7	95	5.1	280664.12095	224	23 720	4916.99073	32
Lithuania	2016	17.985	0.8501	2 327	48.0	101	4.6	233590.99026	347	35 211	6616.08262	40.4
	2018	20.229	0.8374	2 527	52.6	107	4.3	275005.59956	339	35 808	7328.71411	41.4
	2020	22.681	0.7753	2 396	45.3	105	4	302842.05103	416	38 335	8055.7034	36.7
Luxembourg	2016	29.062	4.0566	17 217	49.2	112	7.1	16858.94156	515	1 924	14417.41385	90.9
	2018	28.705	4.1622	14 828	49.0	119	10.8	30 150.0585	432	2 106	14003.43206	91.2
	2020	28.587	4.1771	14 618	52.8	120	9.9	12055.0052	681	2 100	13067.555	90.3
Hungary	2016	11.719	0.9558	1 624	34.7	102	6.5	101503.29522	880	110 391	5255.30192	28.1
	2018	14.818	0.8192	1 879	37.4	105	7	91719.54986	1 130	119 781	5544.49361	29.5
	2020	14.741	0.9138	1 759	32.0	99	5.2	195707.05631	1 022	105 907	5134.664	26.8
Malta	2016	11.745	1.671	4 287	12.7	120	4.2	2 410.76051	110	4 749	3974.78867	75.3
	2018	10.587	1.9342	5 173	10.4	132	8.3	4 053.08142	133	4 949	4183.21326	75.1
	2020	18.095	1.8056	6 847	10.9	132	13.3	3 508.88874	155	4 857	3829.5064	69.3
Netherlands	2016	7.9	4.2781	8 281	53.5	106	28.5	6608883.32712	6 257	97 501	10593.12319	78.1
	2018	7.391	3.8678	8 429	55.9	107	28.9	6523721.46126	7 506	105 760	10033.46844	80.4
	2020	7.745	4.2887	7 175	56.9	99	30	6628356.70835	8 267	104 905	8702.3699	81.1
Austria	2016	25.373	2.2689	7 008	57.6	103	11.2	320436.21124	5 517	48 376	6425.78467	43.1
	2018	24.866	2.361	7 428	57.7	103	11.1	374526.26519	5 483	47 466	6 446.5977	44.4
	2020	21.267	2.1904	7 728	62.3	99	10.8	362788.4812	5 448	49 423	6094.5034	44.3
Poland	2016	16.65	0.6889	4 793	34.8	111	10.2	2948183.97881	2 440	422 007	9295.42745	17.8
	2018	19.039	0.7027	4 621	34.3	114	9.8	2973318.20146	4 325	429 029	9669.40051	19.5
	2020	17.615	0.7649	4 492	38.7	114	7.5	3499502.82211	3 727	437 080	8945.23556	19.3
Portugal	2016	14.959	1.1849	1 427	30.9	104	2.2	890244.3735	1 578	84 026	5601.57926	32.1
	2018	16.808	1.1561	1 546	29.1	111	2.1	876318.6595	2 004	98 264	5789.68129	31.4
	2020	17.097	1.2015	1 612	26.8	107	2.3	931813.31153	1 731	85 587	4815.72136	30.4

Romania	2016	23.154	0.3668	9 012	13.4	110	1.7	329454.09705	899	85 799	5019.54538	10
	2018	23.695	0.4224	10 425	11.1	109	1.5	592488.71594	918	86 347	5300.89443	10.7
	2020	29.616	0.3383	7 338	11.9	107	1.5	638189.4254	1 060	88 583	4964.31556	9.1
Slovenia	2016	14.976	1.5129	2 661	55.5	102	8.7	1202496.58205	117	15 361	6429.75964	47.2
	2018	16.511	1.4702	3 964	58.9	98	10	1295358.36788	188	16 974	6601.09593	46.8
	2020	16.908	1.5784	3 576	59.3	92	9.9	1057830.53143	109	15 918	6233.39852	46.2
Slovakia	2016	13.416	1.2133	1 953	23.0	109	5.3	50108.48008	465	45 547	6 264.8774	42.5
	2018	14.625	1.1894	2 277	36.3	112	4.9	72347.31877	514	49 438	6452.39272	43
	2020	13.278	1.3376	2 340	45.3	109	10.5	36605.52644	484	51 486	5535.97871	42.7
Finland	2016	31.419	0.8967	22 359	42.1	98	5.3	397175.21877	803	41 816	10051.83711	20.2
	2018	35.258	0.8725	23 253	42.3	102	5.9	411818.66295	741	60 513	9712.44723	19.8
	2020	33.617	0.9013	20 993	42.1	95	5.9	379627.50613	728	41 951	7885.26955	18.8
Sweden	2016	25.317	2.0223	14 272	48.4	105	6.8	1455794.89211	2 451	80 333	4869.50259	26.4
	2018	25.79	1.938	13 628	45.8	103	6.6	1471959.98012	1 816	80 130	4533.18216	26.8
	2020	24.932	1.9267	14 664	38.3	92	6.8	1128137.67507	2 200	83 884	3786.83974	23.7

Appendix II

Table B-1. Normalised values of CE indicators

Country/ Criteria	Year	Material Footprint	Resource productivity	Waste generation per capita	Recycling rate of municipal waste	Consumption footprint	Circular material use rate	Trade in recyclable raw materials	Private investment and gross added value related to circular economy	Persons employed in circular economy sectors	Greenhouse gases emissions from production activities	Material import dependency
Belgium	2016	0.370	0.675	0.240	0.761	0.780	0.587	0.246	0.207	0.080	0.539	0.799
	2018	0.416	0.709	0.257	0.774	0.788	0.663	0.227	0.189	0.083	0.543	0.797
	2020	0.370	0.719	0.254	0.731	0.803	0.717	0.294	0.210	0.083	0.490	0.793
Bulgaria	2016	0.496	0.082	0.727	0.452	0.826	0.147	0.022	0.009	0.067	0.545	0.177
	2018	0.601	0.081	0.794	0.448	0.848	0.083	0.024	0.011	0.069	0.536	0.172
	2020	0.586	0.082	0.722	0.501	0.818	0.197	0.026	0.011	0.068	0.464	0.175
Czechia	2016	0.445	0.246	0.103	0.478	0.758	0.250	0.010	0.017	0.158	0.694	0.354
	2018	0.477	0.259	0.153	0.458	0.788	0.350	0.013	0.024	0.158	0.684	0.360
	2020	0.442	0.270	0.155	0.576	0.757	0.387	0.010	0.026	0.162	0.581	0.341
Denmark	2016	0.643	0.491	0.158	0.687	0.833	0.267	0.264	0.072	0.044	0.979	0.388
	2018	0.653	0.495	0.159	0.710	0.833	0.270	0.297	0.079	0.048	0.999	0.418
	2020	0.726	0.500	0.148	0.640	0.825	0.250	0.286	0.089	0.047	0.838	0.406
Germany	2016	0.447	0.572	0.209	0.954	0.795	0.407	0.704	0.475	0.886	0.642	0.440
	2018	0.453	0.604	0.210	0.954	0.795	0.413	0.650	1.000	0.974	0.610	0.440
	2020	0.424	0.627	0.207	1.000	0.787	0.430	0.592	0.914	1.000	0.485	0.435
Estonia	2016	0.682	0.147	0.793	0.397	0.803	0.387	0.004	0.004	0.015	0.991	0.247
	2018	0.860	0.131	0.754	0.398	0.803	0.450	0.005	0.006	0.018	1.011	0.260
	2020	0.790	0.156	0.523	0.411	0.780	0.520	0.006	0.006	0.018	0.559	0.293
Ireland	2016	0.351	0.620	0.138	0.579	0.780	0.057	0.248	0.012	0.037	0.899	0.354
	2018	0.367	0.645	0.124	0.536	0.803	0.053	0.344	0.017	0.040	0.933	0.362
	2020	0.305	0.760	0.140	0.580	0.712	0.057	0.294	0.078	0.043	0.712	0.349
Spain	2016	0.273	0.648	0.119	0.482	0.773	0.273	0.813	0.145	0.530	0.392	0.470
	2018	0.312	0.613	0.127	0.495	0.803	0.300	0.782	0.154	0.558	0.403	0.469
	2020	0.281	0.573	0.096	0.576	0.734	0.310	0.755	0.177	0.587	0.319	0.412
France	2016	0.358	0.711	0.208	0.565	0.765	0.647	0.548	0.587	0.615	0.354	0.429
	2018	0.393	0.696	0.220	0.579	0.758	0.657	0.565	0.533	0.678	0.344	0.416
	2020	0.309	0.708	0.198	0.593	0.696	0.640	0.606	0.592	0.682	0.300	0.397
Croatia	2016	0.354	0.260	0.055	0.299	0.833	0.153	0.032	0.008	0.058	0.310	0.340
	2018	0.388	0.273	0.058	0.360	0.871	0.167	0.045	0.012	0.067	0.312	0.344
	2020	0.371	0.246	0.064	0.420	0.818	0.190	0.069	0.012	0.066	0.308	0.371

Italy	2016	0.310	0.807	0.116	0.653	0.765	0.593	0.551	0.241	0.801	0.384	0.340
	2018	0.329	0.822	0.123	0.708	0.803	0.627	0.566	0.371	0.766	0.380	0.344
	2020	0.279	0.799	0.127	0.731	0.757	0.687	0.513	0.360	0.807	0.342	0.510
Cyprus	2016	0.517	0.335	0.125	0.229	0.788	0.080	0.018	0.002	0.009	0.559	0.368
	2018	0.572	0.317	0.114	0.238	0.818	0.093	0.020	0.003	0.011	0.575	0.373
	2020	0.623	0.309	0.107	0.236	0.757	0.123	0.024	0.001	0.011	0.529	0.355
Latvia	2016	0.407	0.255	0.042	0.358	0.750	0.217	0.023	0.004	0.031	0.356	0.351
	2018	0.497	0.225	0.040	0.358	0.727	0.157	0.029	0.007	0.029	0.384	0.361
	2020	0.512	0.224	0.065	0.565	0.719	0.170	0.042	0.007	0.031	0.341	0.351
Lithuania	2016	0.510	0.198	0.100	0.683	0.765	0.153	0.035	0.010	0.046	0.459	0.443
	2018	0.574	0.195	0.109	0.748	0.811	0.143	0.041	0.010	0.047	0.508	0.454
	2020	0.643	0.181	0.103	0.644	0.795	0.133	0.046	0.013	0.050	0.559	0.402
Luxembourg	2016	0.824	0.946	0.740	0.700	0.848	0.237	0.003	0.015	0.003	1.000	0.997
	2018	0.814	0.971	0.638	0.697	0.902	0.360	0.005	0.013	0.003	0.971	1.000
	2020	0.811	0.974	0.629	0.751	0.909	0.330	0.002	0.021	0.003	0.906	0.990
Hungary	2016	0.332	0.223	0.070	0.494	0.773	0.217	0.015	0.026	0.144	0.365	0.308
	2018	0.420	0.191	0.081	0.532	0.795	0.233	0.014	0.033	0.157	0.385	0.323
	2020	0.418	0.213	0.076	0.455	0.75	0.173	0.030	0.031	0.138	0.356	0.294
Malta	2016	0.333	0.390	0.184	0.181	0.909	0.140	0.000	0.003	0.006	0.276	0.826
	2018	0.300	0.451	0.222	0.148	1.000	0.277	0.001	0.004	0.006	0.290	0.823
	2020	0.513	0.421	0.294	0.155	1	0.443	0.001	0.005	0.006	0.266	0.760
Netherlands	2016	0.224	0.998	0.356	0.761	0.803	0.950	0.997	0.181	0.127	0.735	0.856
	2018	0.210	0.902	0.362	0.795	0.811	0.963	0.984	0.218	0.138	0.696	0.882
	2020	0.220	1.000	0.309	0.809	0.75	1.000	1.000	0.252	0.137	0.604	0.889
Austria	2016	0.720	0.529	0.301	0.819	0.780	0.373	0.048	0.160	0.063	0.446	0.856
	2018	0.705	0.551	0.319	0.821	0.780	0.370	0.057	0.159	0.062	0.447	0.882
	2020	0.603	0.511	0.332	0.886	0.75	0.360	0.055	0.159	0.065	0.423	0.486
Poland	2016	0.472	0.161	0.206	0.495	0.841	0.340	0.445	0.071	0.552	0.645	0.195
	2018	0.540	0.164	0.199	0.488	0.864	0.327	0.449	0.125	0.561	0.671	0.214
	2020	0.500	0.178	0.193	0.550	0.863	0.250	0.528	0.113	0.572	0.620	0.212
Portugal	2016	0.424	0.276	0.061	0.440	0.788	0.070	0.134	0.046	0.110	0.389	0.352
	2018	0.477	0.270	0.066	0.414	0.841	0.073	0.132	0.058	0.128	0.402	0.344
	2020	0.485	0.280	0.069	0.381	0.810	0.077	0.141	0.051	0.112	0.334	0.333

Romania	2016	0.657	0.086	0.388	0.191	0.833	0.057	0.050	0.026	0.112	0.348	0.110
	2018	0.672	0.098	0.448	0.158	0.826	0.050	0.089	0.027	0.113	0.368	0.117
	2020	0.840	0.079	0.316	0.169	0.810	0.050	0.096	0.032	0.116	0.344	0.100
Slovenia	2016	0.425	0.353	0.114	0.789	0.773	0.290	0.181	0.003	0.020	0.446	0.518
	2018	0.468	0.343	0.170	0.838	0.742	0.333	0.195	0.005	0.022	0.458	0.513
	2020	0.480	0.368	0.154	0.844	0.696	0.330	0.160	0.003	0.021	0.432	0.507
Slovakia	2016	0.381	0.283	0.084	0.327	0.826	0.177	0.008	0.013	0.060	0.435	0.466
	2018	0.415	0.277	0.098	0.516	0.848	0.163	0.011	0.015	0.065	0.448	0.471
	2020	0.377	0.312	0.101	0.644	0.825	0.350	0.006	0.015	0.067	0.384	0.468
Finland	2016	0.891	0.209	0.962	0.599	0.742	0.177	0.060	0.023	0.055	0.697	0.221
	2018	1.000	0.203	1.000	0.602	0.773	0.197	0.062	0.021	0.079	0.674	0.217
	2020	0.953	0.210	0.903	0.599	0.719	0.197	0.057	0.021	0.055	0.547	0.206
Sweden	2016	0.718	0.472	0.614	0.688	0.795	0.227	0.220	0.071	0.105	0.338	0.289
	2018	0.731	0.452	0.586	0.651	0.780	0.220	0.222	0.053	0.105	0.314	0.294
	2020	0.707	0.449	0.631	0.545	0.697	0.227	0.170	0.066	0.110	0.263	0.260