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MEASURING CIRCULAR ECONOMY PERFORMANCE IN THE EU: EVIDENCE FROM AN FAHP-WEIGHTED COMPOSITE INDEX

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Abstract. Assessing circular economy (CE) performance across EU countries remains challenging due to the scarcity of country-level composite measures and uncertainty surrounding indicator importance. This study develops a circular economy index aligned with the EU Circular Economy Monitoring Framework. Expert judgments (n = 7) were collected through pairwise comparisons and translated into pillar and indicator weights using the Fuzzy Analytic Hierarchy Process (FAHP). These weights were subsequently combined with Eurostat data and aggregated through TOPSIS to derive national circular economy scores and rankings. The results identify Competitiveness and Innovation as the most important pillar, followed by Global Sustainability and Resilience, Secondary Raw Materials, Waste Management, and Production and Consumption. The highest-weighted indicators include employment in circular economy sectors, material import dependency, and gross value added. Based on the constructed index, Estonia, Latvia, Czechia, and Finland rank highest, whereas Germany, Belgium, and the Netherlands rank lowest within the sample. The proposed index provides a transparent tool for benchmarking circular economy progress and supporting policy prioritization.

Keywords: circular economy development, European Union, circular economy monitoring framework, circular economy index, circular economy performance, FAHP-weighted composite index.

JEL Classification: Q00, Q01, Q56.

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1. Introduction

While seeking alternatives to the take-make-dispose model, countries are increasingly shifting towards the modern circular economy – a model that has become a critical focus of policy and research worldwide, reflecting growing concerns about sustainability, resource efficiency, and climate change. Although circular economy is often associated with waste management, focusing on waste prevention, recycling, as stated by Genta et al. (2025), concept of circular economy has a wider scope along all life cycle of products or services. Circular economy is often described using 6R or more comprehensive 9R frameworks. Circular economy 6R model is comprehensive framework designed to transition from linear to circular economy incorporating six key principles – reduce, reuse, recycle, recover, redesign and remanufacture. This research uses the 6R framework as a practical synthesis that aligns with the logic of the European Union Circular Economy Monitoring framework.

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The *reduce* principle focuses on minimizing resource input, material use, and waste generation. It is foundational for decoupling economic activity from finite resource exploitation and for transitioning from linear to regenerative systems (Bukhari, 2024; John et al., 2025; Zheng & Liu, 2024). Reduction of consumption and raw material can lead to lower emissions, more effective energy consumption and slower environmental degradation. The *reuse* principle extends product life by using items multiple times before moving to other stages or product life cycle. In most cases reuse is more environmentally beneficial since it avoids the energy and other resource use involved in reprocessing (Bubinek et al., 2025; Ma et al., 2021). The *recycle* principle refers to processing waste materials into new products, ensuring that the need for finite resources is limited. It is central to circular economy frameworks, supporting material recovery, waste minimization, and environmental sustainability (Dixit et al., 2025). The *recover* principle refers to recovering remaining value such as energy or materials from waste streams that cannot be reused or recycled (Luo et al., 2024). The *redesign* principle involves rethinking products, processes, or systems to ensure it is made in a way that it is easy to repair, upgrade, disassemble or recycle. It is a proactive strategy that embeds circularity from the concept stage, enabling longer lifecycles (Fröhlich, 2024). The *remanufacture* principle ensures that used products can be restored to like new condition. Same as *reuse* or *redesign* it extends product lifecycle, reduce resource intake and created economic value through multiple use cycles (Mejía-Moncayo et al., 2025; San-Francisco et al., 2020; Steinbiß, 2024).

Back in 2015 the European Union adopted Circular Economy Action Plan as a first comprehensive EU policy tailored to support transition to a circular economy, ensuring global competitiveness and fostering sustainable economic growth and job creation. Later on the EU Circular Economy Monitoring framework was introduced and became a part of EU Green deal. The 6R framework conceptually supports the EU Circular Economy Monitoring Framework, as its indicators reflect key circular principles such as reduction, reuse, recycling, recovery, redesign, and remanufacturing. Although circular economy is gaining popularity and countries are integrating circular economy principles into legal systems as well as such principles are becoming more important for producers, there is still lack of comprehensive ways to evaluate overall circular economy performance. Even though European Union introduced Circular Economy Monitoring framework it does not provide insight into what areas are the most important comparing to other ones. Also there is lack of comprehensive indexes that measure circular economy on country level.

Therefore, this research aims to develop and validate a Circular Economy Monitoring index based on the EU Circular Economy Monitoring framework, using the Fuzzy Analytic Hierarchy Process (FAHP) to elicit and formalize expert-informed weights for the framework's indicators. This research serves as a tool to address which indicator groups should be prioritized when assessing national circular economy performance or developing strategies. The index is designed for country-level comparison and reflects the dimensions captured by the EU monitoring framework; it does not measure firm-level circularity or product-specific circular design directly. Results should therefore be interpreted as a monitoring and benchmarking tool rather than a complete evaluation of all circular economy impacts.

The rest of the paper is organized as follows. The next section presents the theoretical background underlying the study. The third section describes the methodology employed. The fourth section presents the results and discussion, complemented by a graphical visualization of the bibliographic information. Finally, the last section presents the main conclusions of the study.

2. Theoretical background

The circular economy is defined as an economic model that shifts from traditional linear model, aiming to keep products, components or materials in use far as long as possible. This model is restorative and regenerative by design, seeking to decouple economic growth from resource consumption by closing material loops and integrating environmental, economic, and social dimensions (Ferrer-Serrano & Salesa, 2025; Galarza-María et al., 2024). The EU Circular Economy Monitoring framework is a structured system created to measure and asses the progress of EU countries progress towards circular economy. The framework includes various indicators that focus on different aspects of circular economy, such as waste management, secondary raw materials, production and consumption and others. This framework was selected for this study because they are directly linked to the objectives of EU and national circular economy policies and capture different stages of the circular economy transition. Nevertheless, prior research notes that the framework places greater emphasis on downstream waste and material management, while offering more limited representation of product life-extension possibilities (Llorente-González & Vence, 2019; Pacurariu et al., 2021). Full list of indicators is provided in Table 1.

Table 1. EU Circular Economy Monitoring framework pillars and indicators (source: Eurostat, 2026)

Production and consumption	Material consumption	Material footprint
		Resource productivity
		Green public procurement
	Waste generation	Total waste generation per capita
		Generation of waste excluding major mineral wastes per GDP unit
		Generation of municipal waste per capita
		Food waste
		Generation of packaging waste per capita
		Generation of plastic packaging waste per capita
Waste Management	Overall recycling rates	Recycling rate of municipal waste
		Recycling rate of all waste excluding major mineral waste
	Recycling rates for specific waste streams	Recycling rate of overall packaging
		Recycling rate of plastic packaging
		Recycling rate of WEEE separately collected
Secondary raw materials	Contribution of recycled materials to raw materials demand	Circular material use rate
		End-of-live recycling input rates (EOL-RIR), aluminium (excluded)
	Trade in recyclable raw materials	Imports from non-EU countries
		Exports to non-EU countries
		Intra EU trade
Competitiveness and innovation	Private investment, jobs and gross value added related to circular economy sectors	Private Investments
		Persons employed
		Gross value added
	Innovation	Patents related to waste management and recycling

End of Table 1

Global sustainability and resilience	Global sustainability from circular economy	Consumption footprint
		GHG emissions from production activities
	Resilience from circular economy	Material import dependency
		EU self-sufficiency for raw materials, aluminium (excluded)

Production and consumption directly influence resource use, waste generation and are considered as one of the critical components of the circular economy. In circular economy products, materials and resources are kept in use as long as possible to reduce environmental impact and alight with sustainability practices. This includes strategies such as repairing, refurbishing or remanufacturing while extending product lifecycle (Camilleri, 2018, 2019). Although waste is minimised in circular economy, waste management plays important role as well. Recycling is a foundational element of waste management in a circular economy. In circular economy it is important to ensure not only the quantity of recycled materials but also quality so these resources can be easily used again (Worrell, 2024). Effective recycling can lead to significant environmental and economic benefits, such as energy savings and job creation (Bandh et al., 2023). Secondary raw materials on the other hand reduce reliance on imported primary raw materials, mitigates environmental pressures and enhance resource efficiency (Burinskienė et al., 2025; Secondi & Yu, 2025). Besides all benefits of adopting circular economy practices it can also lead to increased competitiveness over traditional linear model, providing more sustainable products for end users (Gupta et al., 2025). Also, circular economy enhances resilience by aiming to decouple economic growth from resource consumption, reduce waste, and foster sustainable development, thereby helping address environmental, economic, and social challenges while maintaining system functionality and promoting long-term ecological balance (Georgescu et al., 2025; Kotorri et al., 2024).

Despite the growing recognition of these circular economy pillars and their policy relevance, there remains no widely accepted approach for evaluating overall circular economy performance at the macro level in a way that enables clear comparison and prioritization. The European Environment Agency provides circular economy country profiles highlighting good practices in EU countries, as well as initiatives that go beyond minimum EU legal requirements for the circular economy, and each country's progress towards it. However, because this work is policy-oriented, it lacks cross-country comparison as well as a unified evaluation of focus areas. Similarly, the United Nations Economic Commission for Europe (UNECE) has guidelines for measuring the circular economy, but country evaluation and comparison remain fragmented.

As stated by de Oliveira Frascareli et al. (2023), macro-level indexes are a useful tool for identifying best practices (benchmarks) and setting targets for less advanced countries. Their proposed circular economy index aims to evaluate circular economy performance in areas such as technology and optimization, resource sources, energy, waste and recycling, and emissions. According to the results, Germany, Austria, Estonia, Latvia, and Sweden are the top-performing EU countries. Although the authors initially identify a quite extensive list of potential indicators from the literature, the final operational index uses a smaller set of macro-level indicators due to data availability, also, their framework differs from Circular Economy Monitoring framework proposed by EU. Kasztelan (2020) proposed an aggregate Index of National Economies' Circularity (INEC) based on 14 circular economy indicators. According to the results, Slovenia, the Netherlands, Belgium, and Lithuania are considered countries with

a high level of circularity. Although the indicators are drawn from the EU Circular Economy Monitoring framework, the index does not use individual indicator weights; instead, it aggregates normalized indicators into a single synthetic score, which is useful for ranking but less direct for identifying the specific focus areas that low-circularity countries should prioritize without additional indicator-level analysis. Mansour et al. (2026) introduced the Circular Index for Resource Conservation and Loop-based Economy (CIRCLE), a novel metric designed to assess circular economy performance. Grounded in the 10R hierarchy, CIRCLE employs a structured point-based scoring system to evaluate practices across all R-principles. Although the proposed index addresses a gap in many circular economy R frameworks by offering an integrated quantitative scoring approach, it is not designed around any single policy framework (e.g., the EU monitoring framework); however, it can be used to support policy benchmarking. Taken together, these indexes offer a strong foundation for benchmarking and comparison, and they also open a clear opportunity to develop next-generation measures that are more closely aligned with the EU monitoring framework and can serve as practical guidelines for countries to quickly identify priority areas for immediate action.

3. Methodology

To evaluate the circular economy performance of EU countries, this research collected and analysed two types of data: an expert survey and statistical data. These were used to assess the relative importance of the selected indicators, develop a circular economy index for EU countries, and evaluate their performance. Two indicators – End-of-live recycling input rates (EOL-RIR), aluminium and EU self-sufficiency for raw materials, aluminium as stated in Table 1 were excluded from the analysis because they do not provide country-level data required for this research.

In the first stage of the research, a quantitative expert survey was conducted. All experts completed identical questionnaires in which they performed pairwise comparisons of the selected circular economy indicators. The number of experts was determined according to Libby and Blashfield (1978), who recommend an optimal panel size of between five and nine experts. Therefore, in the current research, seven experts were selected. In this research, the expert panel included both business practitioners (from private and public sector) and scientists to combine practical implementation insight with scientific and methodological expertise, ensuring that the indicator assessments reflect both real-world feasibility and robust sustainability considerations. Details of the experts are presented in Table 2.

Table 2. General information about experts (source: own)

No.	Education	Experience in the field of CE and sustainability (years)	Sector
E_1	PhD (Economics)	12	Academia
E_2	PhD (Economics)	15	Academia
E_3	PhD (Economics)	10	Academia
E_4	MSc (International Communication)	4	Private Sector
E_5	PhD (Economics)	10	Academia
E_6	PhD (Finance)	5	Public Sector
E_7	MSc (Environmental Science)	5	Private Sector

The Fuzzy Analytic Hierarchy Process (FAHP) was used to process the expert survey data and calculate the weights of the selected indicators. FAHP was chosen because expert judgements may involve uncertainty, which can be effectively captured using fuzzy numbers. In the second step, the multi-criteria decision-making method TOPSIS was applied to assess the current circular economy performance of EU countries and to construct a circular economy index. The combination of FAHP and TOPSIS was selected because the evaluation of circular economy performance requires both the weighting of multidimensional indicators and the ranking of countries based on those indicators. FAHP is suitable for deriving indicator weights from expert judgements, as it allows uncertainty and ambiguity in expert assessments to be incorporated through fuzzy numbers. TOPSIS is appropriate for cross-country comparison because it ranks alternatives according to their relative distance from the positive ideal and negative ideal solutions. Therefore, the combined FAHP-TOPSIS approach enables the construction of a circ5ular economy index that reflects expert-based indicator importance while also providing a transparent and systematic ranking of EU countries. Statistical data were collected from Eurostat. For each indicator, data from the most recent year available in Eurostat were used, because the study aims to provide a current cross-country comparison rather than analyse changes over time. Therefore, the use of different latest available years across indicators does not affect the purpose of the study in the same way as it would in a longitudinal analysis. The exact data year was checked for each indicator during data collection, and no additional standardisation was applied beyond the TOPSIS normalization procedure. Indicators without country-level data were excluded from the analysis.

In the present study, triangle fuzzy numbers based on numerical evaluation are provided for experts' assessment. Triangular fuzzy number $\tilde{A}$ is defined by (l, m, u), and the membership function is represented by the equation (Beşikçi et al., 2016; Dinulescu & Dobrin, 2022; Janjic et al., 2015) (see Eq. (1)).

$$\mu_{\tilde{A}}(x)=\begin{cases}\dfrac{x-l}{m-l}, x\in[l;m];\\ \dfrac{u-x}{u-m}, x\in[m;u];\\ 0, \quad otherwise,\end{cases} \quad \text{with } -\infty<m\le l\le u<+\infty, \tag{1}$$

where: $\mu_{\tilde{A}}(x)$ – triangle-shaped membership function; m – the most probable value; l – smallest likely value; u – the largest possible value.

The evaluation of experts' opinions is conducted using a triangular fuzzy-number scale, which is designed based on a triangle-shaped membership function (see Table 3).

Table 3. FAHP Scale Source: (Cobo et al., 2014)

Intensity of importance of one criterion over another	Fuzzy number, $\tilde{a}_{ij}$	Triangular fuzzy numbers
Equally significant	$\tilde{1}$	(1, 1, 1)
Moderately significant	$\tilde{3}$	(2, 3, 4)
Strongly significant	$\tilde{5}$	(4, 5, 6)
Very strongly significant	$\tilde{7}$	(6, 7, 8)
Extremely significant	$\tilde{9}$	(8, 9, 10)
Intermediate values	$\tilde{x}(x=2,4,6,8)$	$(x-1,x,x+1)$

For the purpose of comparing all the factors to each other and to prepare pairwise comparison matrices, every expert had to make $n(n-1)/2$ comparisons in order to cerate a pairwise comparison matrix that is defined by the Eq. (2) (Cobo et al., 2014).

$$\tilde{A} = \tilde{a}_{ij} = \left(l_{ij}, m_{ij}, u_{ij}\right), \tag{2}$$

where: $m_{ij} = \frac{\sum_{t=1}^{T} a_{ij}^{t}}{T}$; $l_{ij} = \min_{t} a_{ij}^{t}$; $u_{ij} = \max_{t} a_{ij}^{t}$; T – number of experts; t = 1, 2, ... T; $\tilde{a}_{ji} = \frac{1}{\tilde{a}_{ij}}, \forall i, j = 1,2,\ldots,n.$

After the experts complete the mentioned matrices, the aggregated experts' evaluation is computed using the geometric mean approach (see Eq. (3)).

$$\tilde{a}_{ij}^{A} = \left(\tilde{a}_{i1} \otimes \tilde{a}_{i2} \otimes \ldots \otimes \tilde{a}_{in}\right)^{1/n}, \tag{3}$$

where: $\tilde{a}_{ij}^{A}$ – evaluation of aggregated element that belongs to i row and j column; n – the number of pairwise comparison matrices completed by one expert.

Since aggregated experts' evaluations are computed, the fuzzy weights of the criteria are calculated (see Eq. (4)) (Ayhan, 2013).

$$\tilde{w}_i = \tilde{a}_{ij}^{A} \otimes \left(\tilde{a}_{i1}^{A} \oplus \tilde{a}_{i2}^{A} \oplus \ldots \oplus \tilde{a}_{in}^{A}\right)^{-1}, \tag{4}$$

where: $\tilde{w}_i = (Lw_i, Mw_i, Uw_i)$ – the fuzzy weight of i alternative; Mw_i – the best fuzzy estimate; Lw_i – the lowest fuzzy estimate; Uw_i – the highest fuzzy estimate.

In order to prioritise the elements of the structure, Chang's extent analysis is used (Chang, 1996). First, the fuzzy synthetic extent's value $\tilde{S}_i$ with respect to i^{th} object is defined by formula (see Eq. (5)).

$$\tilde{S}_i = \sum_{j=1}^{n} \tilde{a}_{ij} \otimes \left\{\sum_{i=1}^{n}\sum_{j=1}^{n} \tilde{a}_{ij}\right\}^{-1}, \quad i, j = 1,\ldots,n. \tag{5}$$

Second, the degree of possibilities is computed (see Eq. (6)).

$$V\left(\tilde{S}_{i+1} \geq \tilde{S}_i\right) = \begin{cases} 1, \text{ if } M_{i+1} \geq M_i, \\ \dfrac{L_i - U_{i+1}}{(M_{i+1} - U_{i+1}) - (M_i - L_i)}, \text{ if } L_i \leq; U_{i+1}, \quad i = 1,\ldots,n, \\ 0, \quad \text{otherwise.} \end{cases} \tag{6}$$

Third, the minimum value of the degree of possibility is calculated (see Eq. (7)).

$$V\left(\tilde{S}_{i+1} \geq \tilde{S}_i \middle| i = 1,\ldots,n\right) = \min_{i \in \{1,\ldots,n\}} V\left(\tilde{S}_{i+1} \geq \tilde{S}_i\right), \quad i = 1,\ldots,n. \tag{7}$$

Fourth, the weight of alternative w_i is computed (see Eq. (8)).

$$w_i = \frac{V\left(\tilde{S}_{i+1} \geq \tilde{S}_i \middle| i = 1,\ldots,n; i+1 \neq i\right)}{\sum_{g=1}^{n} V\left(\tilde{S}_g \geq \tilde{S}_i \middle| i = 1,\ldots,n; i+1 \neq g\right)}, \quad i = 1,\ldots,n. \tag{8}$$

TOPSIS is the multi-criteria decision-making method which is used to rank (prioritise) the set of alternatives based on the minimisation of distance from an ideal positive solution and the maximisation of distance from an ideal negative solution (Bilbao-Terol et al., 2014). The following steps should be considered for calculations:

Step 1. Compose a matrix of solutions and allocate weights to the criteria used (the weights of the criteria were obtained with the FAHP method).

Step 2. Normalisation of the matrix:

$$n_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}. \tag{9}$$

Step 3. Computation of the weighted matrix:

$$v_{ij} = w_j n_{ij} \text{ for } i = 1,\ldots,m; \quad j = 1,\ldots,n, \tag{10}$$

w_j – j-criterion weight.

Step 4. Identification of the ideal positive and the ideal negative solution.

$$V^+ = \left(v_1^+, v_2^+, \ldots, v_n^+\right) = \left(\left(\max_i v_{ij} \middle| j \in I\right), \left(\min_i v_{ij} \middle| j \in J\right)\right); \tag{11}$$

$$V^- = \left(v_1^-, v_2^-, \ldots, v_n^-\right) = \left(\left(\min_i v_{ij} \middle| j \in I\right), \left(\max_i v_{ij} \middle| j \in J\right)\right), \tag{12}$$

where I associated with maximising, and J with a minimising criterion, $i = 1, \ldots, m$; $j = 1, \ldots, n$.

Step 5. Computation of the distances to ideal positive and ideal negative solutions:

$$S_i^+ = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_i^+\right)^2}, \; i = 1,2,\ldots,m; \tag{13}$$

$$S_i^- = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_i^-\right)^2}, \; i = 1,2,\ldots,m. \tag{14}$$

Step 6. Calculation of the relative proximity to a positive ideal solution:

$$P_i = \frac{S_i^-}{S_i^- + S_i^+}. \tag{15}$$

Step 7. Ranking (prioritisation) of the alternatives according to P_i.

4. Results and discussion

In the first stage of the empirical analysis, judgments from a panel of selected experts were collected to quantify the relative importance of the EU Circular Economy Monitoring framework pillars and indicators. The experts' assessments were aggregated using the Fuzzy Analytic Hierarchy Process, which accounts for uncertainty and imprecision in subjective evaluations. On this basis, normalized weights were derived for each indicator pillar and indicator and the resulting weights are reported in Table 4.

Table 4. Expert-Based Indicator Weights Estimated Using FAHP (source: own)

Pillar	Pillar Weight	Criteria	Criteria Weight	Total Weight	Total Rank
Production and consumption	0.129783	Material footprint	0.088498	0.011486	22
		Resource productivity	0.071385	0.009265	23
		Total waste generation per capita	0.108217	0.014045	21
		Generation of waste excluding major mineral wastes per GDP unit	0.141012	0.018301	18
		Generation of municipal waste per capita	0.140857	0.018281	19
		Food waste	0.128896	0.016728	20
		Generation of packaging waste per capita	0.159582	0.020711	17
		Generation of plastic packaging waste per capita	0.161554	0.020967	16
Waste Management	0.171968	Recycling rate of municipal waste	0.159537	0.027435	13
		Recycling rate of all waste excluding major mineral waste	0.152298	0.02619	14
		Recycling rate of overall packaging	0.139275	0.023951	15
		Recycling rate of plastic packaging	0.206929	0.035585	12
		Recycling rate of WEEE separately collected	0.341961	0.058806	6
Secondary raw materials	0.180693	Circular material use rate	0.045181	0.008164	24
		Imports from non-EU countries	0.280401	0.050666	7
		Exports to non-EU countries	0.432774	0.078199	4
		Intra EU trade	0.241645	0.043663	11
Competitiveness and innovation	0.313074	Private Investments (percentage of gross domestic product (GDP) at current prices)	0.203895	0.063834	5
		Persons employed (percentage of total employment)	0.354725	0.111055	1
		Gross value added (percentage of gross domestic product (GDP) at current prices)	0.288979	0.090472	3
		Patents related to waste management and recycling	0.152401	0.047713	9
Global sustainability and resilience	0.204482	Consumption footprint	0.231571	0.047352	10
		GHG emissions from production activities	0.243314	0.049753	8
		Material import dependency	0.525115	0.107377	2

In the context of circular economy development, the aggregated expert judgments and the FAHP-derived weights rank Competitiveness and innovation as the most important pillar, followed by Global sustainability and resilience. Secondary raw materials ranks third, Waste Management fourth, and Production and consumption is assessed as the least important

pillar. D'Adamo et al. (2024) also report that, based on Analytic Hierarchy Process (AHP) results, the category competitiveness and innovation exerts the greatest impact on circularity, followed by global sustainability and resilience. Similarly, using a fuzzy AHP approach to assign indicator weights, Gallucci et al. (2024) find that according to academic respondents the competitiveness and innovation pillar has strongest potential to influence circular economy performance as well as secondary raw materials according to business respondents. Also, Candan and Cengiz Toklu (2022) identified waste management as the most important pillar based on their fuzzy SMART approach; their analysis considered four criteria - production and consumption, waste management, secondary raw materials, and competitiveness and innovation. Taken together, the reviewed evidence suggests broad agreement that competitiveness and innovation-related dimensions play a central role in advancing circular economy, while differences in the top-ranked pillar across studies point to the influence of expert composition, the selected criteria set, and the applied weighting method on the resulting priorities.

Following the estimation of weights, the multi-criteria decision-making method TOPSIS was applied to compute the circular economy index for EU countries. The resulting scores and rankings are presented in Table 5 and Figure 1.

Table 5. Circular economy index results (source: own)

Country	Index score	Rank	Country	Index score	Rank
Estonia	0.609548	1	Sweden	0.554891	15
Latvia	0.583012	2	Ireland	0.543517	16
Czechia	0.580476	3	Greece	0.543462	17
Finland	0.579646	4	Malta	0.54046	18
Croatia	0.578594	5	Poland	0.537974	19
Lithuania	0.577532	6	Denmark	0.533657	20
Hungary	0.576009	7	Luxembourg	0.533336	21
Austria	0.575981	8	France	0.530218	22
Cyprus	0.574531	9	Spain	0.516624	23
Portugal	0.570731	10	Italy	0.510264	24
Slovakia	0.569092	11	Germany	0.49126	25
Bulgaria	0.566835	12	Belgium	0.475675	26
Romania	0.563445	13	Netherlands	0.413153	27
Slovenia	0.562439	14			

As shown in Table 5 highest-ranked countries are Estonia, Latvia, Czechia and Finland (ranks 1–5). In contrast, the lowest-ranked countries are Germany, Belgium, and the Netherlands (ranks 25–27), indicating substantially weaker performance at the lower end of the distribution. The geographical distribution of the index scores across the EU is also illustrated in Figure 1. The TOPSIS results can be partly explained by performance differences in several highly weighted indicators. Estonia's firs position in the index is strongly supported by its leading value in Persin employed in the circular economy sector as a percentage of total employment at 7.9%, which is far above the EU average of 2.5% (2023). In context, Belgium and the Netherlands perform weakly on this indicator, with values of 1.2% and 1.1%

respectively, which contributes to their low index positions, 26th and 27th. A similar effect can be observed for material import dependency, where higher values have a negative impact on the final index. The Netherlands ranks 2nd in this indicator, with material import dependency of 83.7%, while Belgium ranks 3rd, with 75.8%, both substantially above the EU average of 39.58%. Similar interpretation can be applied to other highly weighted indicators, where strong or weak national performance affects the distance from the positive and negative ideal solutions in TOPSIS.

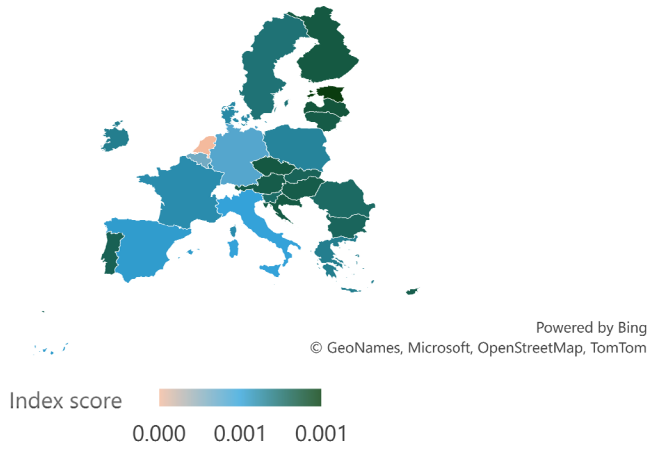


Figure 1. Geographical distribution of index values in the EU (source: own)

The MCDA results reported by D'Adamo et al. (2024) indicate that Belgium is the leading country, followed by Italy and the Netherlands. Overall, Western European countries tend to perform strongly on circular economy policies, whereas Eastern European countries show comparatively weaker results. It is also important to note that the study relies on earlier data and, although it is grounded in the same EU Circular Economy Monitoring framework, it covers a smaller set of indicators. Castillo-Díaz et al. (2024) further show that differences in circular economy performance across EU member states are statistically significant. In their composite ranking, Germany emerges as the overall leader, followed by Italy, France, Belgium, and Spain. However, leadership is not uniform across circular economy dimensions: country positions shift noticeably when the index is decomposed into its component sub-indicators. This matters for interpretation because the composite indicator applies equal weights rather than expert-derived weights. Mazur-Wierzbicka (2021) similarly finds clear cross-country differences in circular economy advancement and identifies a "two-speed Europe," clustering EU-28 member states into two broad groups: frontrunners and slower-transitioning countries. While such clustering is useful for benchmarking, assessing individual country progress in circular economy development requires an index that can track performance consistently over time and across dimensions. However, it should be noted that these results cannot be directly compared, because the studies use different indicators, time periods, weighting approaches, and aggregation methods. Therefore, the comparison is used only to show whether the results follow similar general patterns.

Because circular economy implementation requires wide-ranging changes across society, businesses, and government and such transitions cannot happen overnight, it is crucial to

set clear targets around the most material priorities. In this context, a comprehensive index with transparent weighting can guide long-term circular economy strategy and progress monitoring, even if those priorities need to be updated as conditions and policy goals evolve over time.

5. Conclusions

Aim of this research was to develop and validate a Circular Economy Monitoring index based on the EU Circular Economy Monitoring framework. Two types of data were collected and analysed – expert survey responses and statistical data to assess the relative importance of the EU Circular Economy Monitoring framework pillars and indicators. The derived weights indicate that Competitiveness and innovation receives the highest overall weight, whereas Production and consumption is ranked as the least important pillar. At the indicator level, Persons employed (percentage of total employment), Material import dependency, and Gross value added (percentage of GDP at current prices) receive the highest weights, while Resource productivity and the Circular material use rate receive the lowest weights. These results provide policy-makers with an empirically grounded basis for prioritising circular economy actions and monitoring efforts at the national and EU levels. Based on the TOPSIS results, Estonia, Latvia, Czechia and Finland emerge as the highest-ranked countries in the sample, indicating comparatively stronger performance on the analysed circular economy index. Conversely, Germany, Belgium, and the Netherlands occupy the lowest positions, highlighting a clear performance gap according to the proposed circular economy index.

Several limitations should be acknowledged. the analysis is constrained to a specific timeframe, which may not fully capture longer-term dynamics or structural changes in circular economy development. Also, while expert weighting strengthens the empirical grounding of indicator importance, expert-based assessments may still reflect contextual priorities that could vary across stakeholder groups or over time. Future research could replicate the analysis for different timeframes to capture changes in circular economy performance over time and to assess the stability of rankings. Also, future research could also explore extending the proposed index beyond EU member states, allowing for broader international benchmarking of circular economy performance.

The derived weights can be used by policy-makers to prioritise what to track and where to intervene first within the EU Circular Economy Monitoring framework. Given that Competitiveness and Innovation carries the highest pillar weight, national CE strategies could prioritize measures that build innovation capacity, support circular business models, and scale circular technologies, while continuing to monitor the remaining pillars to avoid overlooking other relevant areas. In practice, the highest-weighted indicators can serve as priority "headline" metrics for setting targets, tracking progress, and assessing policy effectiveness. Such comparative rankings can also help identify best-practice countries whose policy approaches may serve as reference models for lower-performing member states.

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