Measuring Circular Economy in the European Union Based on a Composite Indicator

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Abstract

In the European Union, circular economy has received increasing attention, because of its potential to break with unsustainable production and linear consumption models. The concept of the circular economy came to the fore in the 1960s and typically changes depending on the political, geographical, territorial, social and cultural context. In terms of its operational process, the circular economy, as opposed to the linear economy, sees the economy as a sustainable economic system. The system separates economic growth from the use of resources by reducing the use of natural resources and, in a way, recycling them.

Making progress and measuring performance in the circular economy as an integral part of sustainable development is quite a difficult task, as is getting countries, in this case, the 27 EU Member States, to adapt to this economic model. Measuring the level of implementation of circular economy strategies is still at a relatively early stage, which means that despite efforts, not all countries use the same indicators to measure them. Despite the development of a wide range of indicators, there is inconsistency in their purpose, scope and potential application.

This study examines the circular economy indicators for the 27 Member States of the European Union to develop composite indicators at the Member State level. The research objective can be achieved with the help of secondary data from Eurostat's central database, which is specific to the circular economy. The 25 indicators are structured around four themes, forming the composite indicator's basis. The composite results for the 27 EU Member States show that Belgium, Germany, Denmark and the Netherlands top the rankings, with Romania, Croatia and Malta at the bottom. The existence of these results means that it is easy to measure the performance and ranking of EU Member States in terms of the circular economy.

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Introduction

The scarce resources available on Earth force humanity to meet its needs in scarce ways. To achieve sustainable development, the Transforming Our World: The 2030 Agenda for Sustainable Development was adopted in September 2015. The 17 Sustainable Development Goals (SDGs) aim to inspire people to take action to secure the needs of future generations. In particular, Goal 12 (Responsible Consumption and Production) is the most relevant reference to defining new sustainable strategies for operating and managing systems (Halstenberg et al., 2017). From the 17 SDGs, it can be seen that the 9th one is the one that most closely aligns with the circular economy approach, as it emphasises economic growth and sustainable industrial production. Sustainable development requires radically rethinking national economies (Momete, 2020), including a shift

to a circular economy. The need for change is increasingly pushing the concept of the circular economy model to the forefront, and it is gaining attention in countries worldwide. A global trend leads the international community to explore possible transitions between economic models (García-Barragán et al., 2019). A review of the literature concludes that it has been widely researched as a promising route to sustainable development, but implementing the principles of the economic model is not easy (Janik & Ryszko, 2019).

Adopting a circular economy monitoring system at the European level has provided a tool to monitor how the transition, performance, trends and actions shape economic systems' functioning. In this research, the author attempts to present the theory of the circular economy approach and its measurement potential using composite indicators. During the research, the author sought to answer the question: *Can a single indicator measure the circular economy?* More specifically, can we use a composite indicator developed by scale-alignment transformation? It was done based on a database of 27 EU Member States on the circular economy. The research was based on data from three years (2020, 2021, 2022), and the results showed that, with cautious conclusions, a single value could be used to characterise the Member States' path towards a circular economy.

Literature review

The emergence of the circular economy approach dates back to the 1960s. In the early 1990s, Pearce and Turner (1990) were the first to use the term to describe an economic model based on the first two laws of thermodynamics. In contrast, The Ellen MacArthur Foundation describes the circular economy as an industrial system with regenerative, restorative intent and design (The Ellen MacArthur Foundation, 2013). In contrast to the unsustainable linear economic model, businesses, politicians, and other stakeholders increasingly turn to a circular economy approach. Different strategies have been proposed to transition from a linear to a circular economy, requiring systemic changes (Vanhamäki et al., 2020).

Looking back at the evolution of the circular economy approach, the concept itself came to the fore 5-6 years ago, linking more and more theoretical and practical solutions simultaneously. If we look at its roots, they are based on the concept of sustainable development, more specifically on strong and weak sustainability models. In the case of strong sustainability, the interchange of manufactured and natural capital is not possible, whereas weak sustainability allows it (Washington, 2015).

The definition is used differently by researchers, academics, businesses and other users. Kirchherr et al. (2018) examined 114 concepts for the circular economy, typically built around the 3Rs (reuse, reduce, recycle). The circular economy is an economic system based on a business model that replaces the "end of life" concept by reducing, alternatively using, recycling and recovering materials in production, distribution and consumption. Some researchers, such as Robaina et al. (2020) and Niskanen et al. (2020), use the definition of The Ellen MacArthur Foundation. The circular economy, the cradle-to-cradle model, always goes beyond recycling waste or, more precisely, only doing this in its operations (Mathews & Tan, 2016). The circular economy is seen as a system where materials and resources are involved in processes for as long as possible, are used to the maximum extent and are kept at the highest use value and level.

The circular economy model itself goes beyond the original 3Rs concept, as it is complemented by three more (redesign, remanufacture, and recovery). Not ignoring the study by Potting et al. (2017), they complemented the 6R to 9R by adding refuse, refurbishing and repurposing. In the case of the models's objectives, the economic systems should allow the functioning of natural ecosystems to prevail, which requires that the

resources used by economic activities are used in a closed system. Another goal is to reduce the use of resources by slowing, narrowing and closing resource loops (Wang et al., 2018). Studies on the circular economy focus mainly on existing goals and concrete solutions; they refer to regions, countries, and industrial sectors. According to Janik and Ryszko (2019), the model aims to continuously maintain the highest value and utility of products and components.

Data and methods

Adopting a monitoring system for the circular economy has provided a tool to implement the transition and monitor performance, trends, and actions taken regarding EU legislation. However, the question remains: How can we measure the breakthrough towards a circular economy? Consistently, initiatives cannot be sustained without an evaluation framework. In the study, the author sought to answer the question: Can a single indicator, or more precisely, a composite indicator created using a scale-alignment transformation, provide a measure of the circular economy? The creation was based on Eurostat's circular economy database for the 27 Member States.

The research covers three years – 2020, 2021 and 2022 – as the time series for the other years is incomplete. However, a single figure can be used to assess and analyse the EU Member States' progress towards a circular economy. The results contribute to ranking the 27 EU Member States based on the scores obtained and also help identify each country's performance in the circular economy. The author has sought to create a methodology to facilitate a complex interpretation of the indicators collected by Eurostat using a scale-alignment transformation.

The indicators for the 27 Member States were analysed using Microsoft Excel and SPSS. In terms of their type, the indicators are all high-level metrics; thus, they are suitable for performing the selected scale-alignment transformation. The three years cover 25 indicators each, representing 675 data points. The indicators are structured around five themes: Competitiveness and innovation, Global sustainability and resilience, Production and consumption, Secondary raw materials and Waste Management. The different themes covering the circular economy indicators, which are generally non-repetitive, i.e. each theme occurs only once.

The author of the present study used a scale-alignment transformation to create the composite indicators for the years under study. In the literature reviewed, a parallel can be drawn with the study by Nardo et al. (2005), as the indicator creation phase consists of six steps. After defining the phenomenon, the author selected the European Union indicators for the circular economy and added the missing data to the database. The fourth step was to homogenise the data using a scale-alignment transformation. This method is useful for cases involving several variables, thus unifying the variables' size and unit of measurement. For this purpose, the following formula was defined:

$$CECI = \frac{x_i - x_{min}}{T_x} \quad (1)$$

where CECI, the complex indicator of the circular economy; x_{min}, the minimum value of the circular economy indicator x; x_i, the value of the circular economy variable x and T_x, the range (difference between the maximum and minimum values) of the circular economy indicator (Molnár, 2018). In the scale-alignment transformation, all the indicators in the dimensions will have the same value, between 0 and 1. With this step, the magnitude of the difference between the indicators remains the same. Nardo et al. (2005) weighted and

aggregated the indicators as a penultimate step, but no weighting was done in the present study. However, the author's previous study (Kozma et al., 2022) has shown that different weighting methods can produce almost the same results. As a last step, the CECI indicator was determined.

This methodology can create a composite indicator that ranks and measures the performance of the 27 EU Member States on circular economy activity. Therefore, it can be concluded that there is a large and available database on the circular economy, but conclusions can and should only be drawn based on serious methodological and professional considerations when including it in the analysis and evaluating the results.

Results

The study examines the circular economy indicators of the 27 Member States of the European Union to establish composite indicators at the Member State level. For all 675 indicators per year, a scale-alignment transformation is to be carried out. The alignment has eliminated the distorting effects of differences in magnitude between the series and allowed the aggregation of the transformed data.

Table 1. Country rankings by CECI indicator for the years under review

Country	Value	Ranking $CECI_{2020}$	Country	Value	Ranking $CECI_{2021}$	Country	Value	Ranking $CECI_{2022}$
Belgium	3,98	1	Belgium	3,46	1	Belgium	3,95	1
Denmark	4,29	2	Germany	3,89	2	Germany	4,54	2
Germany	4,48	3	Denmark	4,25	3	Netherlands	5,07	3
Austria	4,83	4	Austria	4,51	4	Denmark	5,13	4
Netherlands	4,93	5	Netherlands	4,71	5	Italy	5,19	5
Finland	5,27	6	Italy	4,86	6	Austria	5,23	6
Luxembourg	5,28	7	Luxembourg	5,04	7	Luxembourg	5,33	7
Italy	5,62	8	Czechia	5,11	8	Czechia	5,64	8
France	5,79	9	Finland	5,22	9	Finland	6,17	9
Czechia	5,82	10	Poland	5,48	10	Lithuania	6,43	10
Poland	5,92	11	France	5,70	11	Poland	6,44	11
Ireland	6,18	12	Spain	5,99	12	Spain	6,56	12
Lithuania	6,21	13	Lithuania	6,02	13	Slovakia	6,58	13
Estonia	6,58	14	Ireland	6,07	14	France	6,73	14
Slovenia	6,61	15	Slovakia	6,07	15	Ireland	6,87	15
Spain	6,69	16	Estonia	6,09	16	Estonia	7,01	16
Slovakia	6,92	17	Slovenia	6,58	17	Sweden	7,58	17
Sweden	7,01	18	Sweden	7,43	18	Portugal	7,86	18
Portugal	7,50	19	Hungary	7,53	19	Bulgaria	7,86	19
Cyprus	8,15	20	Bulgaria	7,58	20	Slovenia	8,33	20
Latvia	8,28	21	Portugal	7,59	21	Cyprus	8,80	21
Bulgaria	8,68	22	Latvia	7,92	22	Hungary	8,90	22
Greece	8,77	23	Cyprus	8,48	23	Latvia	8,98	23

Hungary	8,78	24	Greece	9,52	24	Greece	10,54	24
Romania	11,32	25	Croatia	10,49	25	Croatia	10,97	25
Croatia	11,38	26	Romania	11,61	26	Malta	11,70	26
Malta	12,82	27	Malta	11,94	27	Romania	12,66	27

Source: Authors' editing

After aggregation, the country scores – the basis of the EU ranking – are determined for each of the three years under review (Table 1). For the three years examined – 2020, 2021, and 2022 – the results show that four countries – Belgium, Denmark, Germany, and the Netherlands – are at the top of the rankings, demonstrating their significant progress in the circular economy. In contrast to the leaders, Romania, Malta, and Croatia are at the bottom of the ranking.

The positioning of Member States in the ranking also indicates that the ranking of the EU-27 countries shows very variable steps in the transition to the circular economy model. Germany's high ranking is also because it was almost the first to join the Europe 2020 strategy for a resource-efficient Europe. Since 2012, it has significantly reduced environmental pressures and damage through programmes such as ProgRess I, which can lead to significant resource efficiency improvements. At the same time, the law on the circular economy was adopted. ProgRess II was adopted in 2016 as a successor to the programme, aiming to protect the environment and preserve competitiveness and economic prosperity.

Belgium is already on the way to building a more sustainable society through the circular economy. The federal government and the three autonomous regions - Brussels-Capital, Wallonia and Flanders - have all joined this effort. One of the goals of the circular economy model is zero waste, where all materials are kept in circulation. Belgium was ranked second in the European Union for waste recycling in 2016, providing a strong basis for a major shift to the circular economy model. In the case of Denmark, there is a strong discrepancy between the literature and its ranking, as it is one of the world's most resource-intensive countries. Nevertheless, the author's ranking shows a very good position, which is in itself due to its good performance in indicators other than those used to describe the circular economy model.

The results of this study can best be compared to a previous study by the author, which examined the indicators of the circular economy for the year 2018. Based on this, comparing the ranking of the year 2018 with the three years currently under study, it can be concluded that Spearman's rho (whether there is a significant relationship between the rankings) falls into the high, very-high category (ρ value between 0.78 and 0.84). This significance test, however, shows even higher values for the rankings of the three years currently under study (ρ ranged from 0.95 to 0.98), which means that there is an even closer relationship between them and that the value of the displacement is minimal.

Conclusion

The circular economy is of the utmost importance in the EU and globally. The long-term commitment of countries, and Member States is essential to making it a reality. Monitoring key trends and patterns is essential to understanding how the different elements of the circular economy are developing and have developed over time. Monitoring is also needed to help identify success factors in countries whether the necessary steps have been taken to move forward.

The research question posed by the author suggests that it is possible to create a composite indicator of the circular economy for the 27 Member States of the European Union. However, it is a question for all researchers whether a well-established indicator can characterise the circular economy, as it is a very complex subject. The ranking based on the CECI indicator may, in some cases, as in the case of Denmark, show anomalies because the country is a very large user of resources despite its position in the ranking. Consequently, composite indicators can only be used to draw cautious conclusions.

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