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Original Scientific Article

CIRCULAR ECONOMY AS A FACTOR OF GLOBAL COMPETITIVENESS AND INNOVATION: ANALYSIS THROUGH EUROSTAT INDICATORS

Stoimenov Suzana
University "Union - Nikola Tesla", Serbia Faculty of Entrepreneurial Business and Real Estate Management Belgrade, Serbia
PUC "Naissus" Niš

e-mail: stoimenovsuzana@gmail.com
https://orcid.org/0009-0001-0300-3296

Milica Nestorović
Faculty of Social Sciences, Belgrade, University of Business Academy Novi Sad

e-mail: milica.nestorovic@fdn.edu.rs
https://orcid.org/0000-0002-8663-1721

Milan Brkljač
Alfa BK University, Faculty of Finances, Banking and Auditing , Belgrade, Serbia

e-mail: milan.brkljac@alfa.edu.rs
https://orcid.org/0000-0002-0617-973X

Abstract: The circular economy (CE) is not a goal in itself, but a tool to achieve the decoupling of economic growth from resource consumption. It is not achieved in one step; it represents a long-term and continuous process in which production and consumption models, as well as society, continue to evolve.
In order to monitor the implementation and development of the circular economy, there are indicators that provide insight into the level of circularity of countries for a specific period.
This research aims to continuously monitor the level of circular economy development using Eurostat indicators in the areas of competitiveness and innovation, with a focus on European Union (EU) countries, for the analyzed time period 2018-2020.
The goal of the research is a comparative analysis of the level of circular economy (CE) development in the analyzed countries for a specific time period by identifying key

trends in the areas of competitiveness and innovation since competitiveness is crucial for a country's development and is closely linked to innovation.
Based on the analysis, it was determined that some countries are in an advanced stage of the circular economy, while others are in the early stages. Implementing CE is essential to address the increasing pressure on resources while maintaining economic growth.

Key words: *circular economy, competitiveness, innovation, indicator.*

INTRODUCTION

Reducing resource pressures, fostering innovation, and waste reduction lead to cost savings throughout the supply chain, resulting in economic benefits (S. Stoimenov, et al., 2024). Efficient resource utilization and the Circular Economy (CE) are becoming increasingly influential concepts in the realms of ecological and economic policies (Ewijk, 2018, p. 5), with the necessity for indicators to measure the progress of actions aimed at transitioning towards a CE framework.

Despite the multifaceted definitions and perspectives on CE, there is a crucial need to measure the advancement of CE initiatives comprehensively. To evaluate the progress of CE, reliable indicators are essential. In analyzing the level of progress towards CE, indicators proposed by the European Commission have been utilized, deriving values from existing Eurostat data sources.

Following a comprehensive theoretical review of CE, indicators, and the Eurostat database, the focus shifted towards identifying specific indicators for evaluating the level of CE implementation and developing a methodology for CE assessment.

European Commission-proposed indicators focusing on competitiveness and innovation were employed for this analysis. The Eurostat CE indicators were elaborated through sub-indicators, whose values can be tracked annually.

The comparative analysis of the level of the CE development in EU candidate countries conducted in this study is based on the continuous monitoring of four sub-indicators in the fields of competitiveness and innovation: (I) Gross investment in material goods, (II) Number of employees, (III) Value added at factor costs, and (IV) Patents for technologies mitigating climate change in wastewater treatment or waste management. A time distance of 3 years (2018-2020) was assumed to be sufficient for a comparative analysis of relevant and comparable data in the areas of competitiveness and innovation, leading to reliable conclusions. The research concept involved a comparative presentation of data for all four sub-indicators. During the preparation period of this research (August-September 2025), the data available for comparison include:

PI1 (gross investment in material goods) - up to and including year 2023

PI2 (number of employees) - up to and including year 2023

PI3 (value added at factor costs) - up to and including year 2023

PI4 (patents for technologies mitigating climate change in water treatment or waste management) - up to and including year 2020, necessitating that a comparative overview of all four sub-indicators can be presented for the time frame: 2018-2020.

The research problem can be formulated as follows: which countries can be considered most advanced in terms of CE implementation, and which lag behind in the implementation of CE principles; that is, which countries are leading in CE implementation and serve as examples for other countries that are falling behind in adopting CE practices?

2. LITERATURE REVIEW

2.1 The theoretical concept of the circular economy

The literature covering the Circular Economy is rich and diverse. Based on a detailed review of the extensive existing literature on CE studies, it can be concluded that the Circular Economy does not have a universally accepted definition. There are numerous definitions of the Circular Economy, along with a variety of indicators used to measure CE progress.

There are various interpretations of the Circular Economy by academics, international organizations, and non-governmental organizations. Among the definitions most prevalent in the literature is the one from the MacArthur Foundation, which presents the Circular Economy as an industrial system. The concept of the Circular Economy refers to an industrial economy that is restorative by intention and design. "Products are designed with the intention of easier re-use, disassembly and renewal, or recycling, understanding that reusing significant amounts of materials returned from products at the end of their life cycle, instead of extracting resources, is the basis for economic growth" (MacArthur, 2013, p. 14).

The European Commission conceptualizes the definition of CE around product reuse and waste minimization as per (European Commission, 2015, p. 2): "The Circular Economy aims to maintain the value of products, materials, and resources for as long as possible by returning them into the product cycle at the end of their use, while minimizing waste."

According to the OECD (2022), efficient resource use and advancement in transitioning towards a Circular Economy can not only aid in material security but also enhance environmental and economic outcomes. Therefore, the OECD views CE as both an economic and environmental system.

The Circular Economy Roadmap in Serbia states: "The Circular Economy is recognized as a way to protect companies from resource shortages and unstable prices, thereby enhancing EU competitiveness, creating new business opportunities, and promoting a more innovative and efficient method of production" (Circular Economy

Roadmap in Serbia, 2020, p. 21). Through this document, CE is portrayed as the basis for a country's competitiveness and innovation.

By implementing CE, job creation is boosted, reducing unemployment and poverty. "CE aims for a competitive economy that generates green and decent jobs and maintains resource use within planetary boundaries" (UNECE, 2024, p. 54).

Transitioning to a Circular Economy (CE) model represents a significant challenge involving a multi-step process, emphasizing the separation of economic growth from resource consumption (Gračanac, et al., 2025), while highlighting the need to establish and maintain a resource-efficient and effective economic system by reducing the amount of energy and materials used in production (Rosario, et al., 2024).

The implementation of CE is not an end goal in itself; rather, it contributes to climate protection, resource conservation, increased competitiveness and innovation, as well as job creation.

CE implementation can occur at micro, meso, and macro levels, with this study focusing on the macro level and examining the Circular Economy in terms of competitiveness and innovation through sub-indicators defined by Eurostat. Competitiveness at the micro level pertains to individual company and product competitiveness, while competitiveness at the meso level focuses on the competitiveness of specific sectors or industries. Competitiveness at the macro level relates to a country's competitiveness in the global market.

2.2. The theoretical concept of circular economy indicators

Reliable indicators are necessary to assess progress towards a circular economy. Analyzing indicators of the circular economy can be considered a suitable method for identifying leaders in the implementation of the circular economy. As stated by Trivic and Petrov (2015, p.12), indicators should exhibit the following characteristics:

- Relevance - they demonstrate the essential characteristics of the observed subsystem
- Understandability - they are comprehensible to both experts and the general public
- Reliability - they provide appropriate information
- Data availability

The European Commission published a Monitoring Framework for Circular Economy in 2018, outlining appropriate indicators by areas to track countries' progress in CE implementation. According to Eurostat's 2018 report, the thematic areas for monitoring the development of the circular economy include: Production and consumption, Waste management, Secondary raw materials, and Competitiveness and innovation.

Following the launch of a new Circular Economy Action Plan for a cleaner and more competitive Europe in 2020, a revised framework / new monitoring framework was adopted, incorporating a new dimension of global sustainability and resilience that is added to the existing dimensions of the previous monitoring framework

(production and consumption; waste management; secondary raw materials; competitiveness and innovation). This new dimension focuses on the interconnections among circularity, climate neutrality, and the EU's ambition for zero pollution.

2.3. Eurostat database - a data source for the analysis of the circular economy

The Eurostat database (the official statistical database of the European Union, managed by Eurostat - the statistical office of the European Union) represents a key source for analyzing the circular economy. It provides reliable and internationally comparable statistical data for EU Member States and candidate countries, enabling the continuous tracking of trends over an extended period and facilitating comparisons among countries based on specified indicators. The database is periodically updated and as such is available for data retrieval. The Eurostat database serves as a foundational resource for scientific research and the development of EU public policies in the fields of sustainable development and the circular economy.

Eurostat (https://ec.europa.eu/eurostat/databrowser/view/cei_cie012/default/table?lang=en) governs the field of competitiveness and innovation through which the country's competitiveness and innovation in developing the circular economy are examined using two key indicators:

- Private investments, employment, and gross value added along with corresponding sub-indicators (gross investment in material goods, number of employees, and value added at factor costs)
- Patents related to recycling and secondary raw materials with the associated sub-indicator (Patents for technologies addressing climate change mitigation concerning wastewater treatment or waste management)

Variations in a country's resources, diverse implementation possibilities of the circular economy, and differences in the specific needs of countries influence the level of transition towards a circular economy. By comparing the values of sub-indicators in the field of competitiveness and innovation among countries, it becomes possible to track and compare the level of development of the circular economy across countries. Further analysis of indicators within this field is also feasible.

In order to conduct a high-quality comparative analysis of sub-indicators, it is crucial to consider definitions.

(As per the European Commission, 2018, p.41): "Gross investment in material goods is defined as investments during the reference year in all material goods. This includes new and existing material capital goods, whether purchased from third parties or produced for own use, with a useful life exceeding one year, including non-produced material goods such as land. It is expressed in millions of euros and as a percentage of the Gross Domestic Product."

The number of employed individuals as the total number of individuals working in the field of the circular economy and related jobs, expressed as a percentage of the total number of individuals (European Commission, 2018b, p.43).

Value added at factor costs (European Commission, 2018, p.44) is expressed in millions of euros or as a percentage of the Gross Domestic Product. This sub-indicator represents the gross income from business activities, net of operating subsidies and indirect taxes such as taxes on products associated with turnover, duties, and production-related taxes.

The European Commission (2018, p.46-48) also includes the definition: "The sub-indicator patents for technologies mitigating climate change related to wastewater treatment or waste management are expressed in the number of patents per million inhabitants and in numerical figures.

3. RESULTS AND DISCUSSION

Data transparency regarding the values of sub-indicators PI1, PI2, PI3, and PI4 on the Eurostat website enables the tracking of trends in these sub-indicators during the analyzed period. The necessity and significance of monitoring CE indicators are further confirmed through a detailed analysis of the tabular presentation of sub-indicator values. Table 1 presents the values of sub-indicator PI1 for the period (2018-2020) for the countries under analysis in this study.

Table 1. Sub-indicator values (PI1 2018-2020)

	PI1-2018	PI1-2019	PI1-2020
	Gross investment in material goods (mil Eur/year)		
Belgium	6,551	7,469	7,391
Bulgaria	409	425	308
Czechia	1,557	1,618	1,557
Denmark	2,762	2,493	2,630
Germany	***34,605***	***34,831***	***35,255***
Estonia	240	229	233
Ireland	568	1,693	635
Greece	220	370	327
Spain	**5,427**	**6,023**	**6,063**
France	***19,016***	***20,832***	***21,993***
Croatia	388	342	280
Italy	**11,572**	**13,118**	**8,142**
Cyprus	**94**	**75**	68
Latvia	241	349	215
Lithuania	345	363	306
Luxembourg	425	858	721
Hungary	1,020	1,120	1,009
Malta	**74**	**93**	**76**
Netherlands	**9,344**	**11,346**	**8,666**

Austria	5,613	5,801	5,381
Poland	4,024	4,355	3,266
Portugal	2,011	2,103	1,590
Romania	903	1,098	940
Slovenia	**153**	**146**	133
Slovakia	579	506	460
Finland	803	759	773
Sweden	1,887	2,062	2,126
United Kingdom	***24,818***	***30,147***	***31,869***

Source: author acc. to https://ec.europa.eu/eurostat/data/database), date 16.8.2025

The analysis of current data for sub-indicator PI1 in the period 2018-2020 indicates that Germany had maximum values for the sub-indicator each year, showing a consistent increase in gross investment in material goods. From a competitiveness perspective, this enables more efficient and innovative production, while from a circular economy standpoint, it provides a foundation for the implementation of sustainable and green technologies, extending product life cycles, and reducing resource waste. Very high values were recorded for the United Kingdom, France and Italy. Additionally, values higher than the average for sub-indicator (PI1) were observed for Belgium, Spain, and the Netherlands. These high values for this sub-indicator serve as evidence of significant gross investment in material goods and a high degree of circularity in these countries.

Table 2 presents the minimum, maximum, mean value, and standard deviation for the analyzed period. The average value of the sub-indicator PI1 during the specified period is approximately 4,000.00 million euros per year, with Germany recording nearly 8 times the average value. Countries with minimal values for sub-indicator PI1 include Cyprus, Malta, and Slovenia. Countries with lower levels of circularity measured by sub-indicator PI1 can strive to adopt applied policies and practices from countries with maximum values and work towards improving the development of the circular economy.

Table 2. Min., max, mean and standard deviation for sub-indicators (PI1 2018-2020)

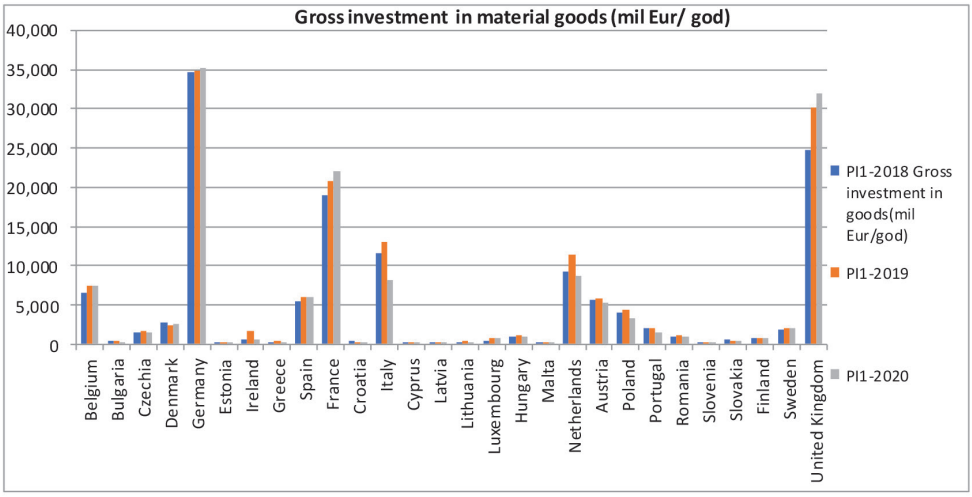
	PI1-2018 ***mil Eur/ year***	PI1-2019 ***mil Eur/ year)***	PI1-2020 ***mil Eur/ year)***
min	74	75	68
max	24,818	30,147	31,869
mean	4,236	4,851	4,495
standard deviation	6745.823267	7910.877568	8072.62127

Source: Authors

Clear strategies and well-defined objectives in achieving CE should be a priority for every country. Germany is a highly developed industrial nation with a sophisticated scientific system. In 2012, Germany adopted the National Resource Efficiency Strategy, aimed at efficient resource use through innovation support and technological development to reduce dependence on limited resources. In 2021, Germany defined the Circular Economy Roadmap for Germany, outlining the necessary steps for transitioning towards a circular economy. As a member of the EU-15 grouping, Germany embarked on the path to sustainable development early on and has a long tradition of shaping waste management legislation that is closely connected to the circular economy.

Through the graphical representation utilizing transparent Eurostat data, it is illustrated that Germany had the highest values for sub-indicator PI1 in the period 2018-2020.

Graph 1. Graphical representation of sub-indicator values PI1 for the period 2018-2020, according to the values from Table 1.



Source: Authors

Table 3 presents the values of sub-indicator PI2. This sub-indicator relates to the number of employees in areas associated with the Circular Economy. An increase in the number of employees in the field of the Circular Economy signifies the development of the Circular Economy within a country, as the implementation of the circular economy as a business model is directly linked to the potential for creating new job opportunities.

Table 3. Sub-indicator values (PI2- 2018-2020)

	PI2-2018	PI2-2019	PI2-2020
	Number of employees (no/year)		
Belgium	64,180	62,497	65,053
Bulgaria	102,997	105,923	101,818
Czechia	134,088	136,915	137,525
Denmark	44,698	44,467	44,584
Germany	**757,319**	**764,026**	**746,870**
Estonia	24,783	25,189	23,835
Ireland	39,154	40,141	36,671
Greece	83,534	85,599	82,112
Spain	**433,421**	**461,948**	**446,859**
France	**533,783**	**535,937**	**565,301**
Croatia	65,707	74,249	72,872
Italy	**518,324**	**544,191**	**537,384**
Cyprus	12,715	13,175	12,483
Latvia	37,238	35,545	33,944
Lithuania	57,748	60,238	58,690
Luxembourg	6,922	7,015	7,980
Hungary	119,335	121,828	120,286
Malta	7,677	8,122	8,348
Netherlands	112,626	115,548	112,792
Austria	64,285	64,973	64,690
Poland	**412,438**	422,230	**417,514**
Portugal	123,193	128,372	127,530
Romania	202,654	206,410	204,328
Slovenia	21,968	23,605	32,014
Slovakia	68,927	69,339	67,009
Finland	29,797	45,210	44,169
Sweden	79,887	81,082	79,310
United Kingdom	**571,526**	**538,095**	**542,918**

Source: Authors acc. to https://ec.europa.eu/eurostat/data/database), date 16.8.2025

Table 4. Min, max, mean and standard deviation for sub-indicator PI2 2018-2020

min	6.922	7.015	7.980
max	**757.319**	**764.026**	**746.870**
mean	168.962	172.210	171.246
standard deviation	207749,6	209014,815	208283,3997

Source: Authors

Current data indicates that Germany ranks first in the number of employees in Circular Economy-related areas during the analyzed period, with significant representation also observed in the United Kingdom, France, Spain, Italy, and Poland. Countries significantly below average in terms of the number of employees include Malta, Luxembourg, Finland, and Cyprus.

In terms of the parameter PI3 - value added at factor costs, Germany exhibits a maximum value well above the average (with an average value of 168,962). Countries with values below average or with the lowest values include Slovenia, Finland, Cyprus, Estonia, etc.

Table 5. Sub-indicator values (PI3 and PI4 - 2018-2020)

	PI3-2018	**PI3-2019**	**PI3-2020**	**PI4-2018**	**PI4-2019**	**PI4-2020**
	Value added at factor costs (mil Eur/year)			No. of patents *(no. of patents/year)*		
Belgium	7,636	8,534	8,605	16.08	15.58	5.49
Bulgaria	911	1,031	1,034	0.5	0	0
Czechia	3,816	4,039	4,022	4.67	9.49	7.16
Denmark	5,563	5,328	5,469	5.63	8.4	2.83
Germany	**76,426**	**80,446**	**83,507**	**84.57**	**103.78**	**45.67**
Estonia	625	663	613	0	0	0
Ireland	14,115	14,534	14,387	1.87	5.42	3.83
Greece	1,137	1,257	1,131	0	0.3	0.5
Spain	**21,437**	**23,211**	21,724	**18.45**	17.68	**21.34**
France	**40,210**	**40,844**	**42,725**	**37.16**	**52.41**	**27.09**
Croatia	1,226	1,348	1,227	0	0	0
Italy	**31,034**	**32,926**	**30,787**	**23.39**	**48.51**	**21.51**
Cyprus	368	405	338	0	0	0
Latvia	522	556	529	0	0	0.5
Lithuania	869	988	970	0	1.5	0
Luxembourg	835	962	877	2.33	2	2.5
Hungary	2,786	2,699	2,540	2	3	0
Malta	407	440	418	0	0	0

Netherlands	14,743	15,164	**15,099**	**33.46**	**33.52**	13.25
Austria	7,455	7,571	7,493	13.01	17.53	6.49
Poland	9,264	10,301	10,265	**22.21**	**20.23**	**17.25**
Portugal	3,213	3,193	2,986	2	3	5.42
Romania	2,266	2,425	2,473	9.5	7.9	5
Slovenia	723	702	756	0	1	1
Slovakia	1,342	1,301	1,284	1.5	3.67	0
Finland	3,424	3,428	3,364	18.63	16.38	15
Sweden	6,481	6,357	6,605	19.17	14.41	4.72
Un. Kingdom	**60,698**	**63,770**	**66,282**	**24.26**	**34.38**	14.12

Source: Authors acc. to https://ec.europa.eu/eurostat/data/database), date 16.8.2025

Table 6. Min, max, mean and standard deviation for sub-indicators PI3 and PI4 2018-2020

	PI3-2018	**PI3-2019**	**PI3-2020**	**PI4-2018**	**PI4-2019**	**PI4-2020**
min	368	405	338	0	0	0
max	76,426	80,446	83,507	**85**	**104**	**46**
prosek	11,412	11,944	12,054	12	15	8
st.dev	18,920.25	19,853.5	20,498.75	18,043	22,700	10,761

Source: Authors

The number of patents serves as an indicator of innovation within the framework of the CE concept. Increased innovative activity is noticeable in Germany, France, Italy, the Netherlands, and the United Kingdom, positioning these countries as leaders in terms of patent numbers. The number of patents in Germany is more than double compared to Italy, indicating greater research and innovation capacity.

Concurrent with the implementation of the European Green Deal and the Circular Economy Action Plan (CEAP), the number of patents in the field of the Circular Economy is expected to increase. This is because the CEAP stimulates innovation, leading to a growth in patents related to CE technologies and the number of patents is a measurable indicator of progress in achieving the goals of the Green Deal. The number of patents in the Circular Economy sector directly reflects how successfully countries are implementing the objectives of the European Green Deal. The European Green Deal and Circular Economy Action Plan aim to transform the EU into a sustainable, climate-neutral and competitive economy.

CONCLUSION

The Circular Economy serves as a vital strategic framework that connects sustainable development, innovation, and competitiveness by promoting production and consumption models based on efficient resource utilization, product lifecycle extension, and waste reduction.

Developed countries began to feel the issues earlier related to

- excessive waste generation
- resource depletion
- environmental pollution
- imbalanced consumption

compared to developing countries, resulting in a faster adoption of the Circular Economy. Countries that joined the EU earlier have made more progress in achieving Circular Economy goals, while those that joined the EU after 2004 are less advanced in the implementation.

The initial steps each country should take in implementing the Circular Economy include developing strategic documents contributing to the developmental path towards the Circular Economy and implementing policies that initiate CE implementation. The CE implementation is essential in order to address increased resource pressures, a growing consumer base, and the escalating effects of climate changes.

Countries lagging behind in achieving goals can improve progress towards CE by emulating leaders in this field. Therefore, identifying leaders in the CE sector is a crucial contribution to advancing the implementation of the Circular Economy in countries that are still catching up.

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