The Development of Circular Economy at EU Level

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Abstract

Consumption and production of goods and services are constantly growing, in order to face the rises and diversification of people's needs, which are continually developing. Also, the raw materials needed in production are declining and waste is increasing, affecting the achievement of sustainable development. Most waste ends up in the environment, instead of being reduced. This is why, actions have to be taken to improve production processes, technologies, business strategies, and to change consumption patterns for achieving sustainability. This paper aims to assess the evolution of circular economy's indicators, such as the ones proposed by the European Commission through its circular economy's action plans. Based on the indicators that are tracked, we analyzed the evolution of the indicators during the past 4 years, identifying the member states with the highest and also the lowest growth rates, in order to assess the possibility of achievement of the circular economy's goals in the EU action plans.

Keywords

Sustainability, consumption, production, recycling, raw materials, waste
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Introduction

The notion of "circular economy" refers to an economic system aimed to eliminate waste and the continual use of resources. This concept was developed long time ago, but it has been more intensely discussed since the 1970s (Wautelet, 2018). The circular systems employ reuse, sharing, repair, refurbishment, remanufacturing and recycling to create a closed-loop system, in order to minimize the use of resource inputs and generating waste, pollution and gas emissions (Geissdoerfer, et al., 2017). Its purpose is to ensure sustainable consumption and production. The European Commission implemented a policy in this regard in 2015, called Circular Economy Action Plan, which included 54 actions (European Commission, 2021). In order to assess the development of circular economy, EU reports several indicators, which target self-sufficiency for raw materials, waste generation, recycling and recovery rates, and other topics related to trade, investments and research output. The aim of the paper is to assess the circular economy's indicators at EU27 level during 2015-2019, by conducting a secondary data analysis of the main indicators in time and space.

The paper is structured as follows. Firstly, a literature review is performed on circular economy's targets and reporting indicators topics from both qualitative and quantitative perspective. The quantitative approach is based on a bibliometric analysis, which investigates the research areas, citations and other trends of the scientific publications on circular economy's indicators during 2015-2019. Further, we performed an analysis of EU27 indicators relevant to indicate the development of

circular economy for the past years. Finally, the conclusions highlight the recommendations proposed by the authors in improving the achieving of circular economy's objectives.

Theoretical background

The bibliometric analysis used in this section aims to expose the evolution of scientific literature related to simultaneously considering the terms "circular economy" and "indicator*" on Web of Science platform during 2015-2019. The search criteria generated a total of 339 papers in the analyzed time frame, from 15 documents in 2015 to 155 records in 2019. The continually increasing trend of publications shows that the research on circular economy' indicators are receiving more and more interest from both academia and various international or national organizations, such as European Commission – with approximately 13% of 339 papers, National Natural Science Foundation of China – with 8.8% of 339 records, and Portuguese Foundation for Science and Technology – with 2.6% of 339 documents published on Web of Science database. Most of the publications are in the field of environmental sciences, engineering, and other topics of science technologies – with more than 40% of the papers per each research are, while 12.6% of all are in the area of business economics. Further, more than 98% of the 339 scientific publications are written in English, while approximately only 2% are in Spanish, Russian, and Portuguese, making the research accessible unfortunately only to the people who know these languages, especially predominantly English. In terms of the document type, 79.3% are articles, 15.9% are proceedings papers, and the rest of them are reviews, book chapters and editorial materials.

The most prolific authors in discussing the research on the circular economy's indicators are Geng Y. – with 11 papers, De Meester, S., Dewulf, J. Irabien, A., and Liu Z. with 5 papers each. However, the most cited authors and papers, with over 100 citations, are those of Ghisellini, et al. (2016), Genovese, et al. (2017), Krausmann, et al. (2017), Elia, et al. (2017), McDowall, et al. (2017) and Pauliuk (2018).

Some of them illustrate aspects of circular economy at theoretical level (Ghisellini et al., 2016), while others (Genovese, et al., 2017) gather more practical evidence for better substantiating the importance of this model. Ghisellini, et al. (2016) presents a review on circular economy for highlighting the good practices in achieving the goals of this model. Genovese, et al. (2017) show that circular economy can provide better advantages than a conventional one when comparing 2 case study at industrial level. Krausmann, et al. (2017) makes an inventory of the use of material and energy resources at global level, while assessing the uncertainties related to the stocks relations. McDowall, et al. (2017) emphasize the similarities and differences of circular economy policies between Europe and China, in terms of conceptual understandings from the discourses of policies, media and research publications, as well as in terms of the assessment indicators used for evaluating the circular economy's progress. Finally, Elia, et al. (2017) and Paulik (2018) conclude that the quantitative assessment tools for circular economy are not currently consistently and entirely considered, although existing methods and indicators, like resource depletion ones and other assessment standards, could be used.

With the help of VosViewer software (Van Eck and Waltman, 2016), the main topics of all 339 papers on circular economy's indicators extracted from the title and abstract sections from Web of Science are illustrated in Figure 1.

There were 9259 terms identified in the publications presented in figure 1 and 297 terms occur more frequently than 10 times. The words with more than 200 appearances are: indicator, circular economy, system, analysis, waste, result, and model, while the ones with occurrences between 100 and 200 times are: study, paper, approach, development, product, process, resource, framework, sustainability, method, material, level, use, production, industry, value, economy, assessment, performance, country, China, impact, city, strategy, efficiency, and sector.

Methodology

This paper presents a secondary data analysis of the main EU indicators for assessing the progress of circular economy. Considering the fact that the first Circular Economy Action Plan at EU level was implemented for 5 years, this analysis emphasizes the assessment of the areas targeted in it for all the 27 EU Member States during 2015-2019.

Results

The analysis of the production and consumption indicators relevant for circular economy

The EU self-sufficiency is different for each raw material. In 2016, there are listed 24 raw materials. The highest rates of self-sufficiency are in the case of limestone, with the highest percentage (97.1%), cobalt (68.2%) and gallium (65.8%). The lowest rate of self-sufficiency with 0% has it the borate, dysprosium, europium, magnesium, molybdenum, neodymium, phosphorus, tantalum, and yttrium. These differences could come from low consumption of products which contain raw materials. This data shows that the EU is not 100% self-sufficient, which means that some raw materials are very likely to come from outside the European Union.

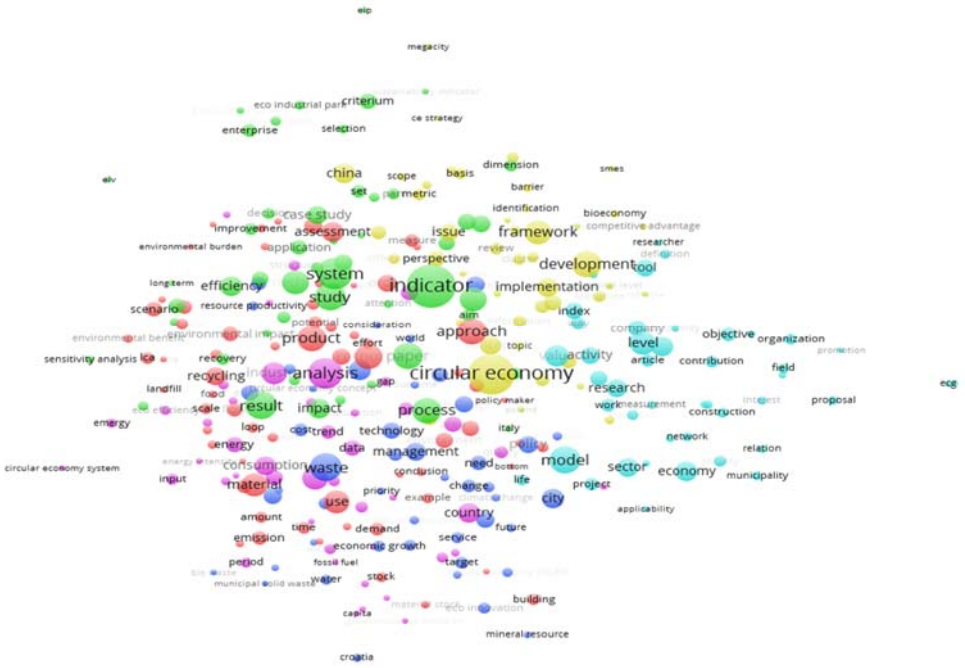

Figure no. 1. Main topics of Web of Science titles and abstracts on circular economy's indicators

Source: developed by authors with VosViewer software based on Web of Science data

The analysis of the municipal waste per capita in 2015 shows that countries like Romania with 247 kg per capita, Poland with 286 kg pe capita, and Czechia with 316 kg per capita have the lowest generation of municipal waste. Though, in 2019, Romanian volume of municipal waste increased with 13.36%, in Czech Republic it grew with 58.22%. On the other hand, countries like Denmark, Germany and Cyprus, with the highest municipal waste pe capita (up to 620 kg per capita) in 2015, do not have a relevant change in waste generation. For example, Germany has reduced the amount of waste generation with only 3.63%. These indicators illustrate the differences in consumption patterns and economic wealth, but also in how municipal waste is currently collected and managed. (European Commission, 2018). Overall, the EU average of municipal waste per capita increased by 4.58% during 2015-2019, even if it aims to reduce it with 50%, according to the New Circular Economy Action Plan.

Generation of waste excluding major mineral wastes per GDP unit was compared only for 2016 and 2018, since there is no available data for 2015, 2017 and 2019. In 2016, Estonia had the highest rate of 653 kg per thousand euro, followed by Bulgaria with 418 kg per thousand euro and Poland with 184 kg per thousand euro. In 2018, these three countries still had the highest rate. Instead, countries like Denmark and Ireland have 35 kg waste per thousand euro, followed by Luxemburg with 32 kg per

thousand euro. The evolution of this indicator between 2016 and 2018, shows that countries like Malta, Ireland and Luxemburg had the highest drop of the indicator (around 15% and 20%), while Bulgaria, Greece and Portugal registered the highest increases of waste generation excluding major mineral waste per GDP unit. The fluctuation between Member States reflects the waste intensity of the economy and provides a measure of "eco-efficiency". According to the targets, EU did not have a positive growth, which is a good thing, but it decreased only by 1.49% from 2016 to 2018.

The waste generation excluding major mineral wastes per domestic material consumption tracks the efficiency of EU material consumption by comparing the tons of waste generated to domestic material consumption. In 2016, Estonia reached a 33.3% level, followed by Netherlands with 25.6%, and Belgium with 25.4%. In 2018, these three countries remained with the highest percentages, even if Estonia's evolution decreased by 3.6%. Among the 27 EU member states, Romania had a good "material efficiency", as the indicator was less than 5%. At EU level, this indicator decreased by 0.3% during 2016-2019, pointing out a low performance.

The highest percentage of recycling rate of municipal waste in 2015 was reached by Germany (66.7%), Austria (56.9%) and Slovenia (54.1%), and the lowest percentage was reached by Malta (10.9%), Romania (13.2%) and Slovakia (14.9%). Until 2019, Germany, Austria and Slovenia remain the countries with the higher rates of this indicator (over 57%). For Malta and Romania, the rates were lower than 11.5%. Slovakia improved its efficiency in recycling municipal waste, reaching 38% in 2019. Overall, at EU level, this indicator had an increase of 2.8% during 2015-2019, until 47.7%. Moreover, the EU aims at recycling up to 65% until 2030, which means that it should increase by 5.65% per year to reach the 2030 target.

Considering the available data for 2016 on the recycling rate of all waste excluding major mineral waste, Slovenia had the highest rate (80%), followed by Belgium and Netherlands with more than 72%. The lowest level was registered in Estonia (10%), Romania (30%) and Cyprus (31%).

Regarding the recycling rate of packaging waste by type of packaging indicator, in 2016, Belgium had a rate of 81.5%, while Czechia, Denmark, Netherlands and Sweden had a rate above 71%. In 2018, Cyprus increased its rate with 10.40% (from 59.8% to 70.2%), followed by Finland with an increase of 9.3%. However, there were also countries that registered decreases, such as Denmark, with 6.2%. At EU level, the evolution registered a small decrease, of 0.29%. The EU Members should achieve an increase of 70% by 2030, therefore it will be very challenging and difficult to accomplish it by 2030 if the rhythm is maintained.

Regarding the rate of e-waste, Bulgaria has registered the highest rate of recycling in 2015, of 96.5%, compared to all member states, but in 2018, its rate was 66.7%, decreasing with 29.8% in time. Another decrease was registered in Slovenia (29.55%). Also, there were countries which increased their rates, such as Croatia with 25.1%, and Denmark with 24.5%. At EU level, this indicator increased by 3.2%, from 35.7% in 2015 to 38.9% in 2018. Considering the overall recycling rate, by 2030 EU could reach the increase of only 9.6%.

The recycling rate of bio-waste at EU level had an increase of 16% in the studied period, being led by countries like Czechia, who registered a major increase (330%), and Slovenia, Lithuania, Greece and Croatia, who registered increases of over 114%. Yet, Cyprus and Estonia registered decreases of 57.14% and 30.76%. This indicator reached the best performance so far from the analyzed indicators.

The data from 2016 and 2018 indicate an important evolution of recovery rate of construction and demolition waste indicator. For example, Bulgaria registered a decrease of 66%, Romania 11% and Finland 13%. There were no exponential increases, except in Sweden, were the recovery rate was up by 29%. The target for 2020 aims at recovering 70% of this type of waste. Yet, the overall EU increase is of only 1% from 2016 to 2018. Therefore, it may be considered a target hard to achieve until 2030, if the current trend is kept as it is.

The analysis of the indicators on recycled materials

The "contribution of recycled materials to raw materials demand-end of life recycling input rate" is used to measure how much recycling does contribute to creating new materials (with reference to materials such as aggregates-crushed, aluminum, beryllium, bismuth, cobalt, copper, natural rubber,

nickel etc.) On one hand, the highest percentage of recycling rates were for nickel, yttrium, zinc and molybdenum with over 30%. On the other hand, the lowest percentage of recycling rates were in the case of beryllium, cobalt, dysprosium, gallium, lithium and natural rubber by 0%.

According to our analysis, circular material used rate in EU registered an increase of 0.7%. Countries such as Greece, Malta and Belgium had the highest increases, between 2.3% and 5.6%. Yet, Bulgaria, Latvia and Poland registered decreases between 0.7% and 1.8%.

The "trade in recycled raw materials" indicator measures the quantities of selected categories and by-products that are shipped between the EU Members and across the EU borders. Malta increased this indicator by 955% between 2015 and 2019, Estonia by 440.98% and Greece by 22.24%. Cyprus and Poland registered decreases of 55%. At EU level, there is a general decrease of 3.86% in the analyzed period, which means that in the next few years, EU has to increase its rate, in order to achieve a significant change.

The analysis of the competitiveness and innovation indicators

The highest increases for the private investments in circular economy between 2015 and 2018 were registered in the case of: Hungary by 97.61%, and Cyprus, Croatia and Romania between 41 and 47%. The EU had an overall increasing share of 13.84%. Until 2030, following the same trend, the EU could reach a growth of 152.24%.

Innovation is the key player of patents related to recycling and secondary raw materials. This could make a transition towards a circular economy, by creating new technologies, processes, services and business models. Countries such as Hungary, Belgium, Spain and Denmark registered the highest increases in patents related to recycling and secondary raw materials, between 163% and 46%.

Conclusion

The indicators proposed by the European Commission have to be significantly adjusted (positively or negatively) for achieving the aimed objectives. There are a lot of Member States which have to act immediately, because the differences on the evolutions are high, and the generated gaps are difficult to overcome. The most developed countries, like Italy, France, Belgium, Germany or Netherlands already took action in this direction and the results are starting to show on some indicators, such as recycling rates. Countries like Romania, Bulgaria, Cyprus, have very low rates on recycling, but also the consumption indicators are lower than central-western countries. These differences may come from the lack of legislative frameworks, but also due to the fact that the member states that did not reach the targets have joined later the European Union compared to central and western countries. So, countries which developed through production, trade and high-level services are the largest waste generators, but also, they are able to reuse and recycle raw materials, managing to capitalize on waste, save money and contribute to sustainability. These countries will have the most important contribution in reaching the targets by 2030.

Considering the evolution of the circular economy indicators that were previously analyzed based on Eurostat (2021), we suggest that the EU should consider developing more assessment indicators and other tools for understanding the development of circular economy, similar to what Paulik (2018) emphasized. Further, it should take more concrete actions in stimulating the achievement of the objectives by 2030. At the same time, this model should be aligned at international level, because only a shared and common international effort could generate a significant result, especially when all sustainability aspects are considered.

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