Prijaté/ Received:04.09.2024
Recenzované/ Reviewed: 17.09.2024
DOI: https://doi.org/10.24040/aap.2024.21.1.69-82

CIRCULAR ECONOMY - PERCEPTION OF ITS ESSENCE AND COMPARISON OF SELECTED INDICATORS IN SLOVAKIA AND THE CZECH REPUBLIC

CIRKULÁRNA EKONOMIKA – VNÍMANIE JEJ PODSTATY A POROVNANIE VYBRANÝCH INDIKÁTOROV NA SLOVENSKU A V ČESKEJ REPUBLIKE

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Abstract
The circular economy (CE) is crucial for achieving sustainable development by minimizing waste and optimizing resource use. This study aimed to compare the perception of the CE concept in the Czech Republic and Slovakia through a questionnaire survey and analyze the development of selected CE indicators. The respondents were stakeholders involved in the relevant issue, meeting the condition of operating within the forestry and wood industry sector in the analyzed countries. The results revealed that a majority of respondents in both countries were familiar with the CE concept and recognized its importance for sustainable development. Statistical analysis indicated positive trends in Resource Productivity and Circular Material Use Rate in both countries, highlighting progress towards sustainable economic practices. However, the need for continuous awareness-raising efforts remains evident.

Keywords: circular economy, sustainable development, resource productivity, circular material use rate, comparative analysis
JEL Classification: Q01, Q57

INTRODUCTION

The consumer society, of which we have been a part for decades, operates within the linear model of the economy known as the cycle "extract-produce-consume-throw." However, this model is unsustainable due to its reliance on abundant, low-cost materials and energy. Spending limited resources and generation of waste without opportunities for further use are thus another a blow to the environment, the planet, and future generations. Alivojvodic and Kokalj (2024) emphasized that the gradual depletion of resources, their inefficient utilization, and increasing consumption highlight the need for implementing a circular economy, which paves the way for sustainable development. Similar arguments can be found in other studies (Raworth, 2017; Giannakitsidou et al., 2020; Halkos and Aslanidis, 2023; Korhonen et al., 2018).

There is a growing interest in circular economy worldwide, driven by its global impact and the unwritten image of companies in the eyes of their customers. All over the world, companies are trying to apply innovative technologies with the possibility of reusing certain components or entire products at the end of their life cycle or consuming them energetically. Even within national economies, there is an effort to gradually implement CE principles. CE indicators are important tools used to measure progress in achieving the goals of this concept. Although the adoption of circular economy principles in Slovakia is still nascent, it poses a significant challenge that warrants detailed attention. The aim of the article is to analyze the results of a questionnaire survey to present a comparative analysis of the perception of CE fundamentals within the forestry and timber complex of Slovakia and the Czech Republic, as well as the development of selected circular economy indicators in both countries.

1. CIRCULAR VS. LINEAR ECONOMIC MODEL

Waste production is one of the adverse consequences of the traditional linear production process that has been implemented in recent decades. The model of extracting primary materials, their consumption, and waste disposal has increased based on economic growth, which means a burden on the environment due to the rapid increase in the volume of waste produced. Many authors have highlighted this fact in their studies (Cerqueira et al., 2021; Magazzino et al., 2021; Namlis and Komilis, 2019). As a practical example of using the linear versus circular economic model, the following fact can be presented:

- Linear model: product - a disposable plastic spoon, which has the advantage of being low-cost and easily accessible. The disadvantage is that it is made from limited raw material resources (oil), involves logistics that include thousands of kilometres of distribution, has short-term rapid use, and results in plastic waste (landfills, microplastics that burden nature).
- Circular model: product - a reusable spoon made from bio-based sources (wood-plastic composite, bioplastic such as corn-based, recycled bioplastic, wood, bamboo). The disadvantage is the higher cost and lower availability. On the other hand, the advantages include the use of renewable raw materials, reduced logistical distance, reusability, recyclability, and potential compostability as a source of nutrients.

The concept of the CE is based on material efficiency, reducing resource waste, and reusing waste in the life cycle of a new product. In practice, it implies reducing waste to a minimum. According to Pánik and Jantová (2019), the circular economy operates in closed cycles, both biological and technical. The concept of waste is eliminated because the CE views it as a resource. Examples include using textiles as a source for building materials, food waste as a source for the paper industry, and bio-waste as a source for agriculture.

Summarizing information from various sources (Murray et al., 2017; Hobson, 2016; Ellen MacArthur Foundation, 2022; Koval et al., 2021; Atstaja et al., 2022), the following main principles of the CE can be identified: the use of renewable energy sources, renting and sharing products, designing products with longer lifespans, ecological sustainability, easy repairability, the ability to disassemble into individual materials, and a high level of recyclability. These principles are associated with many benefits of using CE principles (Berry et al., 2022; Bianchi and Cordella, 2022; Cantzler et al., 2020; Mies and Gold, 2021): economic (efficient resource management, waste valorisation, cost reduction), environmental (renewable energy, reduced demand for primary resources), and social (creating new jobs, strengthening the position of the local community, building cohesion).

The CE model represents an important contribution to building a sustainable economy; however, there are several barriers that slow down its implementation in business practice. These barriers can be divided into four groups (Klepek, 2018): cultural, market, technological, and regulatory. Similarly, the study by Ferronato et al. (2019) mentions various factors that slow down and prevent the implementation of CE in practice. These include low awareness of the essence of CE, insufficient regulation and legislation, the need for funding for implementation, and inadequate coordination of cooperation between sectors.

The challenge for the CE concept is the need to change consumer behaviour, the essential transition from a linear to a circular economic model, especially in terms of resource depletion and environmental protection. Despite the barriers and risks, CE presents a future challenge for all countries due to the benefits it brings. According to World Economic Forum (White Paper, 2023), the CE represents a $4.5 trillion opportunity by 2030. Its potential is therefore obvious. Numerous studies have focused on the perception of the circular economy, engaging stakeholders from various sectors. For instance, research by Geme et al. (2023) revealed that only 27% of respondents were familiar with the term, while just over 60% had heard of CE and understood only its basic concepts. Similarly, Sijtsema et al. (2019) found that respondents lacked a precise understanding of CE, with widespread ignorance prevailing.

Various indicators are associated with CE, serving to measure and evaluate progress and success in achieving CE objectives. Many organizations address the issue of CE indicators, including the Statistical Office of the EU (ec.europa.eu), OECD (www.oecd.org), Ellen MacArthur Foundation (www.ellenmacarthurfoundation.org), and the World Business Council for Sustainable Development (www.wbcsd.org). The monitoring framework in the Eurostat database, which has become the primary information database for our survey, currently contains 5 main groups in which the relevant indicators of CE development are included. The monitoring framework currently consists of 5 thematic sections (Production and consumption, Waste management, Secondary raw materials, Competitiveness and innovation, Global sustainability and resilience) with a total of 22 statistical indicators (ec.europa.eu/eurostat/web/circular-economy/database). The research utilized two selected indicators, “Resource Productivity” and “Circular Material Use Rate”, for the comparison of development. These indicators allow for an effective comparison of the sustainability and efficiency of resource use between the Czech Republic and the Slovak Republic.

2. DATA AND METHODOLOGY

The aim of this paper is to assess the knowledge and perception of the concept of circular economy among stakeholders in the forestry and timber sector in the Slovak Republic and the Czech Republic, and to compare selected CE indicators between these countries. For data collection related to the perception of the CE, a questionnaire survey was utilized. The aim of the survey was to identify stakeholders’ perception of the concepts of sustainable economy, bioeconomy, and CE in the forestry and wood industry sector in Slovakia and the Czech

Republic. The basic condition for selecting respondents was their job position within the forestry and wood-industry sector, specifically in the areas of agriculture, forestry, wood-processing industry, as well as public administration or education in the analyzed countries. Data collection took place from October 2023 to January 2024, with respondents being contacted by phone or email. The basic requirement was their involvement in the relevant issue and the relevance of their job position in the sectors of agriculture, forestry, wood processing industry, as well as public administration or education. The questionnaire was shared on the Google Forms platform and was part of the Erasmus+ FRAME grant tasks "Forests, climate change mitigation and adaptation: Higher Education Cooperation in the Mekong region" and project Vega no. 1/0093/23.

The subjects of the analysis of the perception of the concept of circular economy among stakeholders and the selected circular economy indicators were two chosen countries. As an argument for selecting these countries, similarities in their historical backgrounds influencing their socio-economic development, as well as similarities in industrial focus and significant orientation towards agriculture, were chosen. The paper analyzed the CE indicators Resource Productivity (section Production and Consumption) and Circular Material Use Rate (section Secondary Raw Materials).

As part of the initial statistical processing, the data are described using frequency tables with absolute and relative frequencies, which are graphically represented by means of bar charts. Further, selected methods of inductive statistics are used - a linear model of the time series trend and a test of the difference of two correlation coefficients. The trend represents the long-term change in the level of a time series. At the beginning of analysis, the line chart is used to show how a variable changes over time - to see whether a trend exists. In the case of a linear relationship between the dependent variable and the time variable, the regression model is defined by the linear regression line (Kohler, 1988):

$$y_i = \beta_0 + \beta_{1ti} + \varepsilon_i$$

where: β_0 *is intercept,* β_1 *is slope, and t =1, 2, ..., T.* The slope β_1 of linear regression trend represents the average change in dependent variable resulting from a unit change in time.

As part of testing the statistical significance of a regression linear trend, the null hypothesis is stated in the form H_0: $\beta_1 = 0$ against the alternative H_1: $\beta_1 \neq 0$. The test statistic *t* is defined as follows (Kohler, 1988):

$$t = \frac{b_1}{s_{b_1}}$$

where s_{b1} *is the variance of the sample regression coefficient* b_1.

To verify whether the change in the time variable affects the dependent variable in two population sets in the same way, we perform null hypothesis testing H_0: $\beta_{1,1} = \beta_{1,2}$ against alternative hypotheses H_1: $\beta_{1,1} \neq \beta_{1,2}$. The decision to accept or reject is determined by the test characteristics given by the relation (Lind, 2020):

$$t = \frac{b_{1,1} - b_{1,2}}{s_{b1,1-b1,2}}$$

where b1,1 and b1,2 are the sample regression coefficients and sb1,2-b1,2 is defined as follows (Lind, 2020):

$$s_{b1,1-b1,2} = \frac{(n_1-2)s^2_{rez1}+(n_2-2)s^2_{rez2}}{n_1+n_2-4} \cdot \left[\frac{1}{\sum_1^{n_1}(x_{i1}-\overline{x_1})^2} + \frac{1}{\sum_1^{n_2}(x_{i2}-\overline{x_2})^2}\right].$$

When the null hypothesis is rejected, the linear regression trends are significantly different, and thus the average change in the dependent variable corresponding to a unit change over time in the first and second time series is not the same. In hypothesis testing 5% level of significance was used as a decision rule. All analyses were performed in statistical software STATISTICA 14.

Based on the previous study review, the following research question (RQ) and hypotheses (H1, H2) were formulated:

RQ: Are there differences in the perception of the CE concept in the analyzed countries? H1: We assume that the regression trend of the circular economy indicator: resource productivity is different across the analyzed countries. H2: We assume that the regression trend of the circular economy indicator: circular material use rate is different across the analyzed countries.

3. RESULTS AND DISCUSSION

3.1 Perception of the Circular Economy Concept

The aim of examining this issue was to compare the perception of the essence of the circular economy in the Czech Republic and the Slovak Republic based on a questionnaire survey, as well as to compare the development of selected circular economy indicators. The questionnaire survey was conducted in cooperation with the Czech University of Life Sciences in Prague.

When analyzing the knowledge and perception of the CE concept in Slovakia, the sample consisted of 68.50% men and 31.50% women out of a total of 130 respondents. In the Czech Republic, the sample consisted of 61.00% men and 39.00% women out of a total of 100 respondents. Due to the application of the basic condition for selecting survey respondents, based on their involvement in the relevant issue and especially the nature of their job positions in the agriculture, forestry, wood processing industry, as well as in public administration or education, it was not possible to identify the size of the basic population in both countries. Therefore, we did not proceed with testing the representativeness of the sample. Most of the respondents in Slovakia were university-educated (86.20%), while 13.10% had secondary education. In the Czech Republic, 94.9% of respondents declared university education, and 5.1% declared secondary education. The question regarding the knowledge of the CE concept revealed that the majority of respondents in both countries (73.1% in Slovakia and 68% in Czech Republic) have already encountered this concept and believe they understand what it means (Table 1). Nevertheless, the survey revealed the need to continuously raise awareness about this concept in the future. At the same time, the results presented a higher level of understanding of the CE concept compared to the studies by Geme et al. (2023) and Sijtsema et al. (2019).

Table 1 Comparison of knowledge of the CE concept in Slovak and Czech Republic

	Slovak Republic	Czech Republic
Agree	95 (73.1%)	68 (68.0%)
Partly agree	27 (20.8%)	26 (26.0%)
Do not agree	8 (6.2%)	6 (6.0%)

Source: authors´ elaboration

Another partial question of the survey dealt with the connection between the circular economy and sustainable development. Respondents had the opportunity to express their level of agreement with the statement that the CE concept is an important part of sustainable

development. The rating scale was a numerical scale from 1 to 6, where 1 represented minimal agreement and 6 the highest level of agreement with the statement. In Slovakia, 51.5% of respondents expressed the highest level of agreement, while in the Czech Republic it was 33.7%. However, the second highest level was indicated by as many as 35.7% of Czech respondents, which was 7.2% more than Slovak respondents. At the second highest value – 5, 37 representatives from Slovakia and 35 from the Czech Republic agreed. The presented values in both countries indicate the recognition of the importance of the circular economy as an integral part of a sustainable economy. Some authors also affirm that sustainability can help organizations to implement circular economy (Kravchenko et al., 2019, Sehnem et al., 2019). According to Sehnem et al. (2019), sustainability is a driver of CE and is mediated by innovation, Kravchenko et al. (2019) complement that CE is a stepping-stone towards sustainability.

Another analyzed question focused on the relationship between the circular economy and other concepts (bioeconomy, green economy) that aim to mitigate the negative impacts of climate change and improve adaptation to climate change. Respondents again had a numerical scale from 1 to 6 to express their level of agreement with the statement (figure 1).

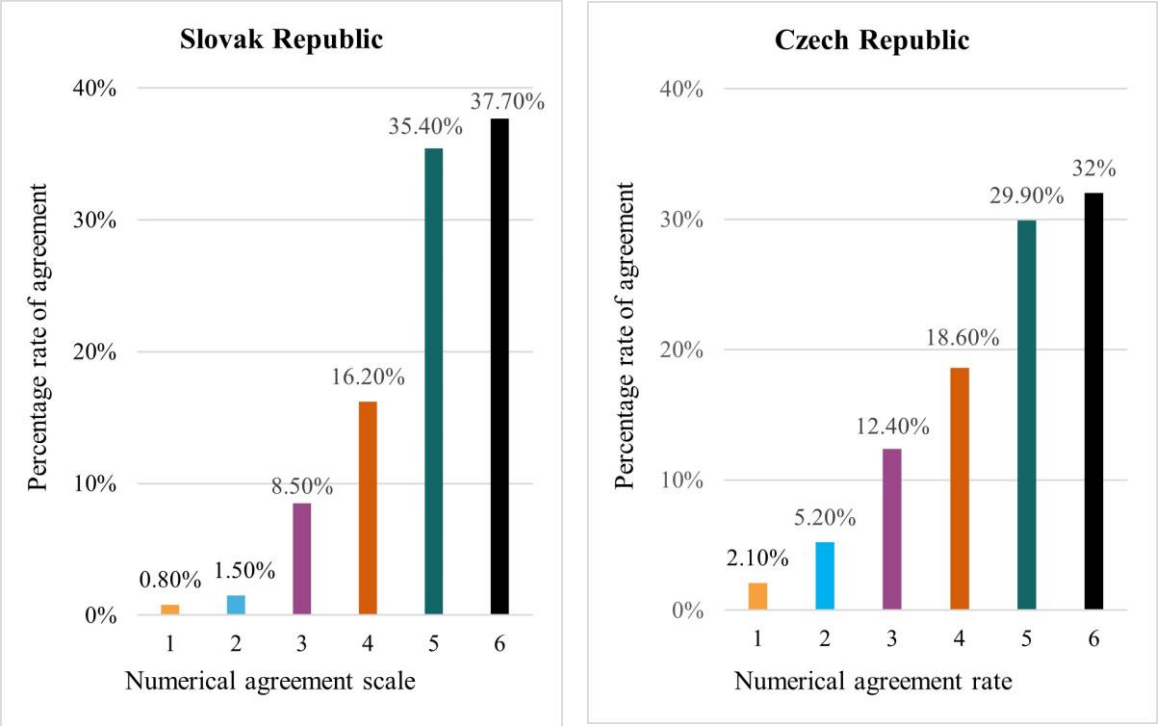

Figure 1 The relationship of CE with other economic concepts in Slovak and Czech Republic
Source: authors´ elaboration

In the case of the Slovak Republic, 37.7% of respondents indicated the highest level of agreement, while in the Czech Republic it was 32%. The second highest level of agreement was expressed by 35.4% of respondents in Slovakia and 29.9% in the Czech Republic. The lowest level of agreement was expressed by only 0.8% of representatives in Slovakia and 2.1% of Czech respondents. This indicates an important connection between the circular economy and other concepts in the effort to minimize negative climate impacts. In this context, the following can be stated. From the point of view of the mentioned concepts, the

green economy can be perceived as a more general concept, taking into account that the CE and the bioeconomy are its components (Gregorio et al., 2018). While the bioeconomy emphasizes the use of renewable biological resources from land and sea such as crops, forests, fish, animals, and micro-organisms to produce food, materials, and energy (European Commission), the circular economy focuses on the efficient use of all resources and the minimization of waste through recycling and reuse. These approaches are interconnected, sharing the common goal of achieving sustainable development. The synergy of these two concepts is expressed in the term "circular bioeconomy", which can be defined "as the sum of all activities that transform biomass for use in different product streams such as materials, chemicals, biofuels, and food" (UNECE, 2021). In the context of the RQ, it can be stated that there are no significant differences in the perception of the CE concept in the analyzed countries.

3.2 Analysis of Selected CE Indicators of the Slovak Republic vs Czech Republic

The following part of the study focuses on the statistical analysis of the development of selected CE indicators in the evaluated countries. The selected indicators are visually presented through line graphs, followed by elementary measures of relative growth dynamics – growth rate, increment rate. From the methods of inductive statistics, tests of linear regression trends and tests of the conformity of regression coefficients are applied. Figure 2 presents the development of the Resource productivity indicator. The Resource productivity indicator, tracked by Eurostat, measures the efficiency of material use in an economy. It is defined as the ratio of gross domestic product (GDP) to domestic material consumption (DMC). DMC represents the total amount of materials directly used by an economy, including raw materials extracted domestically and all physical imports minus physical exports. In both countries, a possible upward trend is indicated. In the Czech Republic, there was mainly a regular annual increase in the value per kilogram of extracted material, with the only significant decline recorded in 2010-2011. The development of values in the Slovak Republic was more variable, with a noticeable increase in 2011-2012 and 2018-2019.

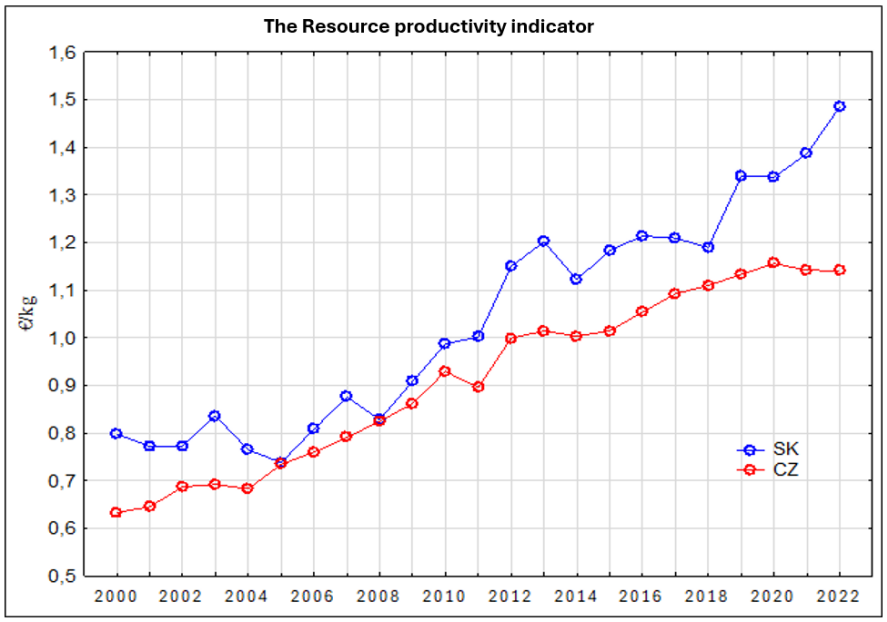

Figure 2 Development of the circular economy indicator "Resource productivity" in the analyzed countries

Source: authors´ elaboration

From the given annual data, selected relative growth dynamics were subsequently calculated, and based on the growth rate, the highest percentage increase in values in both countries was in 2012 compared to the previous period (Slovakia 15%, Czech Republic 12%). The second largest increase in values in Slovakia in 2019 reached 13%, while in the Czech Republic it was only a 2% increase. The observed upward trend was then modeled using simple linear regression methods. Based on the p-values (table 2), it was confirmed that there is a statistically significant positive linear trend in both analyzed countries.

Table 2 Results of the statistical significance test of the linear regression model of the trend development of the time series for the years 2000-2022

Resource productivity (€/kg)	Sample size-N	Intercept-b_0	Slope-b_1	t-test	P-value
Slovak Republic	23	0.642	0.033	15.97	0.000
Czech Republic	23	0.596	0.026	28.86	0.000

Source: authors´ elaboration

From the data in Figure 3, it is possible to observe the regression trend of the circular economy indicator: resource productivity. According to the test results, we accept hypothesis H1 about the difference in regression coefficients in this case, which means that we consider the slopes of the regression lines to be different. An argument in favour of accepting this hypothesis is also the test of the conformity of regression coefficients (table 3, P-value 0.005). Based on this statement, we can conclude that the annual increase in resource productivity does not change equally in both countries. The average growth in resource productivity in the Slovak Republic is €0.033/kg per year and is indeed more significant compared to the Czech Republic with an average value of €0.026/kg per year.

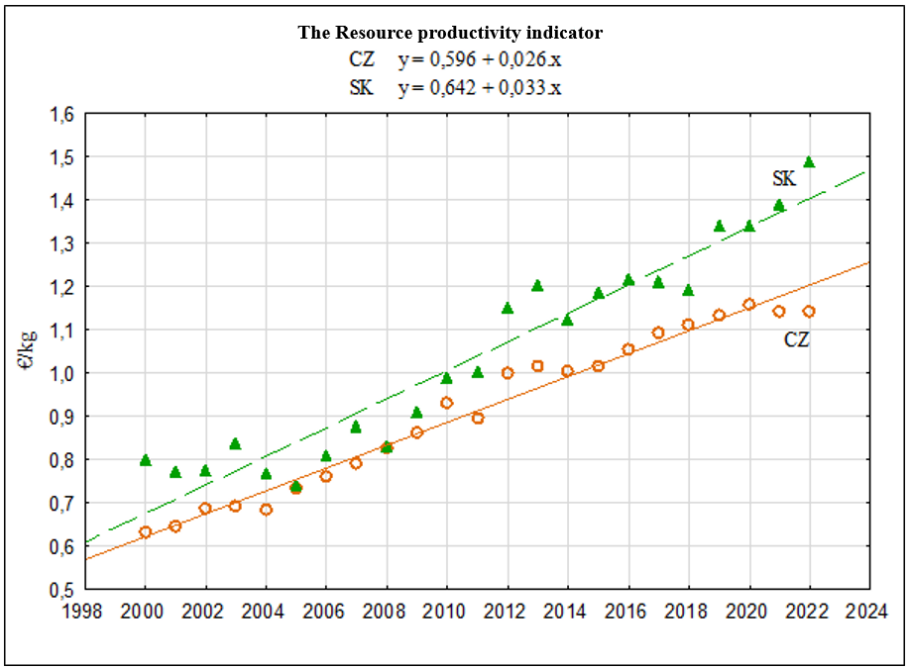

Figure 3 Linear regression trend of Resource productivity development
Source: authors´ elaboration

Table 3 Results of the test of conformity of regression coefficients of two basic sets – CE indicator Resource productivity

Resource productivity (€/kg)	Sample size N	Slope b1 SVK	Slope b2 CZE	t-test	Degree of freedom	P-value
Slovak Republic vs Czech Republic	23	0.033	0.026	-2.96	42	0.005

Source: authors´ elaboration

Figure 4 presents the development of another analyzed indicator: Circular material use rate. The Circular material use rate indicator, tracked by Eurostat, measures the share of material recovered and fed back into the economy, thereby reducing the need for extracting primary raw materials. This indicator is part of the monitoring framework for the circular economy and focuses on the thematic area of secondary raw materials.

In both countries, a probable upward trend is emerging. In the case of the Czech Republic, a higher rate of circular material use was observed throughout the entire period. In Slovakia, lower percentage values were recorded, but there was a sharp increase from 2018 onwards. The increased rate could have been caused by the adoption of measures from the Slovak Economic Policy Strategy 2030, which focuses on waste as a source of secondary raw materials.

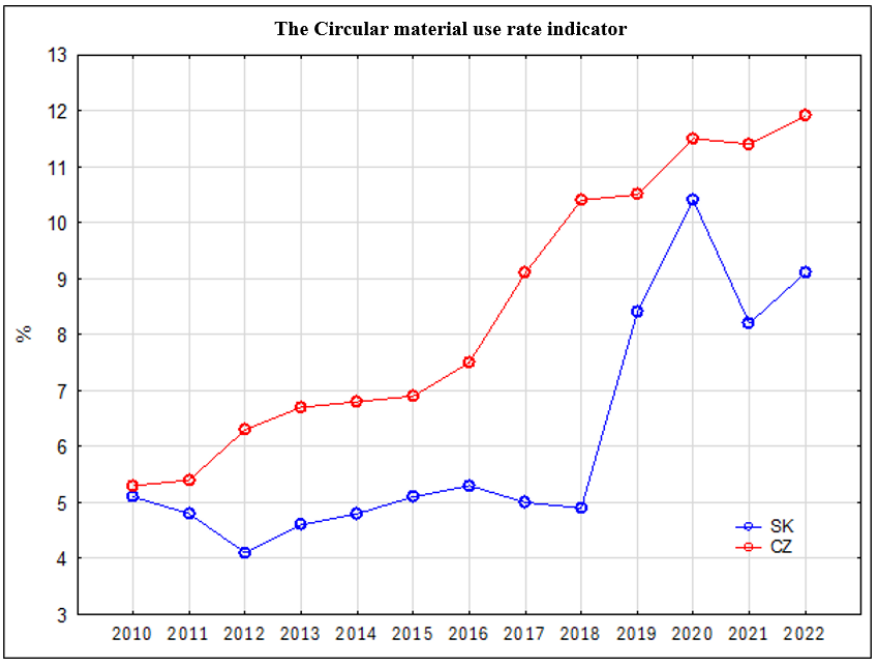

Figure 4 Development of the circular economy indicator "Circular material use rate" in the analyzed countries

Source: authors´ elaboration

From the given annual data, selected relative growth dynamics were subsequently quantified. A significant difference was observed in 2012, when Slovakia saw a 15% decrease in the circular material use rate. In the Czech Republic, an increase of 17% was recorded during this period. Conversely, in 2019, the highest increase in Slovakia reached 71%, while in the Czech Republic it was only a 1% increase. The maximum decrease in 2021 in Slovakia was 21%. In the case of the Czech Republic, the highest increase compared to the previous

period was 21% in 2017. For modeling the upward trend, simple linear regression methods were used, as with the previous indicator. However, for this indicator, a smaller number of available values were recorded over a period of 13 years. Based on the p-values (table 4), it can again be confirmed that there is a statistically significant positive linear trend.

Table 4 Results of the statistical significance test of the linear regression model of the trend development of the time series for the years 2010-2022

Circular material use rate (%)	Sample size-N	Intercept-b_0	Slope-b_1	t-test	P-value
Slovak Republic	13	-1.119	0.427	4.39	0.001
Czech Republic	13	-1.948	0.611	14.98	0.000

Source: authors´ elaboration

Figure 5 presents the linear regression trend of the CE indicator, specifically the rate of circular material use. Based on the results of the regression coefficients conformity test (Table 5, p-value 0.095), the hypothesis H2 was rejected. In this case, it was confirmed that the annual increase in the rate of circular material use changes approximately equally in both Slovakia and the Czech Republic. In Slovakia, the average annual increase is 0.6%, and in the Czech Republic, it is 0.4%, with these differences not being significant.

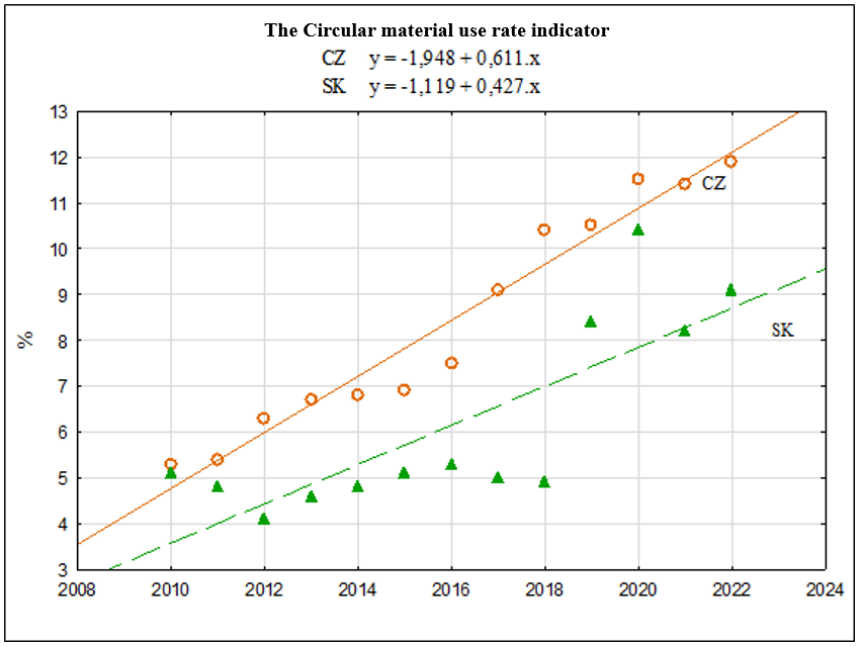

Figure 5 Linear regression trend of Circular material use rate development
Source: authors´ elaboration

Table 5 Results of the test of conformity of regression coefficients of two basic sets – CE indicator Circular material use rate

Circular material use rate (%)	Sample size N	Slope b1 SVK	Slope b2 CZE	t-test	Degree of freedom	P-value
Slovak Republic vs Czech Republic	13	0.0427	0.611	1.75	22	0.095

Source: authors´ elaboration

Several authors have analyzed and compared CE indicators. For instance, Smol (2023) identified national strategies (roadmaps) for implementing CE in selected European Union countries. Additionally, this paper presents an inventory of performance indicators mentioned in the selected CE national strategies. Mazur-Wierzbicka (2019) focused on a multidimensional comparative analysis of the implementation of the circular economy in EU countries. The study by Halog and Anieke (2021) is also noteworthy as it reviews existing and relevant published studies on the circular economy in developed countries, including Australia, and discusses the implications for Korea. Vranjanac et al. (2023) compare the development of circular economy indicators in the EU-28 countries using the Eurostat database. The results agree that within the compared countries, there are always certain differences in the level of selected indicators, and it is up to the policy of each state how it fulfills this monitoring framework. It is evident that both analyzed countries show significant potential for fulfilling the principles of CE in indicators other than those presented in this study.

CONCLUSION

The study aimed to compare the perception of the circular economy concept in the Czech Republic and Slovakia through a questionnaire survey and to analyze the development of selected CE indicators. The survey revealed that a significant majority of respondents in both countries were familiar with the CE concept and believed they understood its meaning. The survey also examined the relationship between the CE and sustainable development. A substantial proportion of respondents in both countries agreed that the CE is an essential part of sustainable development. This underscores the recognition of the CE's importance in achieving sustainable economic practices. Furthermore, the study explored the connection between the CE and other concepts such as the bioeconomy and the green economy, which aim to mitigate the negative impacts of climate change. The results indicated a strong agreement among respondents that the CE is closely linked to these concepts, highlighting its role in promoting environmental sustainability.

The statistical analysis of selected CE indicators, such as Resource Productivity and Circular Material Use Rate, revealed positive trends in both countries. For instance, the Resource Productivity indicator showed a statistically significant positive linear trend in both countries. Similarly, the Circular Material Use Rate indicated a growing trend, with Slovakia experiencing a higher average annual increase compared to the Czech Republic.

In conclusion, the findings of this study emphasize the importance of the circular economy in both Slovakia and the Czech Republic. The positive trends in CE indicators and the strong recognition of its significance among respondents suggest that both countries are making progress towards more sustainable economic practices. However, continuous efforts are needed to further raise awareness and integrate the CE concept into various sectors to achieve long-term sustainability goals.

ACKNOWLEDGEMENTS

We wish to thank VEGA agency, project No. 1/0093/23 "Research of the potential of the circular economy in the Slovak business environment in the production of innovative products based on recycled materials wood -rubber –plastic" and project UNIVNET for the support by research.

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