



THE INFLUENCE OF CIRCULAR ECONOMY ON SUSTAINABLE DEVELOPMENT: EUROPEAN AND SERBIAN EXPERIENCE

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Abstract: The paper analyzes the potential of sustainable economic growth based on the implementation of circular economy principles. In the last decade, the circular economy has received rising attention worldwide as a way to replace the current production and consumption model based on a linear economy. By promoting closing the loop by applying the 6 R's (rethink, refuse, reduce, reuse, recycle, and repair) with a particular emphasis on municipal waste, sustainable development aims to achieve better harmony between the environment, economy and well-being of society. EU member states have implemented various policies and initiatives, such as the new Circular Economy Action Plan, which aims to increase recycling rates, reduce landfilling and promote eco-design. Additionally, the circular economy plays a central role in the new European Green Deal in its aim to tackle climate change. The Republic of Serbia has also recognized the importance of sustainable development and has developed its National Circular Economy Strategy, which aims to promote economic, social and environmental sustainability. Using European Statistical Office data from 27 European countries pertaining to the years between 2014 and 2021, this paper aims to examine the relationship between the circular economy, economic growth. Based on the cluster analysis, EU members are divided into two groups. Also, the results obtained from the regression analysis for EU member states were compared with the current state of application of the circular economy in Serbia, using comparable available data. Although the implementation of the circular economy in Serbia lags behind the EU average, there has been some progress in this period, with untapped potential for further growth. The results suggest that a circular economy provides opportunities to create competitive advantages and promote sustainable economic growth, which can be beneficial to decision-makers.

Keywords: circular economy, economic growth, cluster analysis, regression analysis, European Union, Serbia.

1 Introduction

In the last few decades, the circular economy has received more and more attention. In the light of rising awareness of the negative effects of emissions of greenhouse gases and global warming, the circular economy has become a crucial part of the green transition. Linear economy traditionally follows the "take-make-dispose" step-by-step plan. This means that raw materials are collected, then transformed into products that are used until they are finally discarded as waste. In this economic system, value is created by producing and selling as many products as possible without considering their durability.

The Ellen McArthur Foundation, leading circular economy think tank, defines circular economy as "as system that is restorative or regenerative by intention and design that can be achieved by eliminating waste through the superior design of materials, products, systems and, within this, business models." (The Ellen McArthur Foundation, 2013: 7). The main alternative to traditional linear models of production and consumption is the circular economy. The circular economy tries to close the loop by applying the 6 R's: 1) Rethink - Refers to rethinking the way we design and produce products, and questioning the current linear model; 2) Redesign - This means designing products and services with circularity in mind, considering factors such as durability, reparability, recyclability, and ease of disassembly; 3) Reduce - This involves reducing the amount of resources used in production and consumption; 4) Reuse - This refers to finding ways to extend the life of products by reusing them; 5) Repair - This involves repairing products that are broken or damaged rather than disposing of them and buying new ones; and 6) Recycle - This means recycling materials and turning them into new products, keeping them in use, and reducing the need for virgin materials (Kirchherr, Reike and Hekkert, 2017).

The EU has made the transition to a circular economy a key priority, as evidenced by recent EU policy (European Commission, 2020). Many national governments also adopted laws and strategies regarding the implementation of the circular economy. Serbia, as an EU candidate country, adopted some legislation in 2020, such as the



National Circular Economy Strategy, which sets out a roadmap for transitioning to a circular economy (Ministry of Environmental Protection of the Republic of Serbia, 2020).

The main benefit of the transition to a circular economy, according to Taranic, Behrens and Topi (2016) can be summarized in three pillars. Firstly, it creates environmental benefits through reduced impacts and reduced resource usage. Secondly, it provides cost savings, particularly in terms of reducing natural resource needs. And thirdly, it creates new markets; the implementation of the circular economy provides economic benefits in terms of jobs and wealth creation.

2 Theoretical background

In recent years, there has been much research regarding the relationship between the circular economy and macroeconomic growth. In their paper, Busu and Trica (2019) validate that the circular economy has a positive impact on economic growth using panel data for the period of 2010 to 2017. Trica, Banacu and Busu (2019) concluded that resource productivity, environmental employment, the recycling rate of e-products, and environmental innovation have a positive effect on GDP growth based on panel data analysis from 2007 to 2016. Shpak et al. (2021) showed that recycling rates have a major influence on the trade in recyclable raw materials throughout the EU and that the circular economy may support sustainable development and minimize waste. Recycling has been the most popular circular approach for feeding materials back into the system, according to Mhatre et al. (2021) which indicated that the circular economy has gained traction in the EU. Due to government laws and regulations, the adoption of the CE action plan, which was suggested in 2015, has allowed circular processes in several industries. A number of policy proposals made by Hartley, van Santen and Kirchherr (2020) like the growth of circular procurement, tax breaks for circular goods, and assistance for eco-industrial parks, may hasten the transition to a circular economy. Gregson et al. (2015) emphasizes the difficulties in creating circular economies in the EU, demonstrating that they arise from a triad of politically shaped markets, material characteristics, and ethically constrained material circuits. Teekasap (2018) concluded that economies in nations without resource constraint issues can profit over time from reduced raw material costs and larger sales volumes. Practices in the circular economy, according to Ferrante and Germani(2020), can directly boost economic expansion. Hysa et al. (2020) showed a significant and favorable association between economic growth and the circular economy, stressing the critical importance of sustainability, innovation, and financial investment in zero-waste projects for the advancement of wealth. According to Vuță et al. (2018), the rate at which municipal garbage is recycled, as well as other aspects like research and innovation, and patents pertaining to recycling, all have a favorable impact on resource productivity and economic growth.

The motivation for this article is to estimate the potential for economic growth in Serbia based on the implementation of the circular economy. There has been much research regarding the implementation of the circular economy in Serbia. According to Vukadinović et al. (2018), the circular economy is a relatively new idea in Serbia, but it is being implemented on a practical and institutional level, and there is potential for further growth. In the previous period, significant funds from EU funds for member countries and Serbia were used to finance development projects (Kragulj and Parežanin, 2011). Mihajlov, Mladenović and Jovanović (2021), in their paper, focus on waste management as the first step towards the implementation of the circular economy, while Ilić and Nikoli (2016) analyze waste management in cities in Serbia, comparing it to Ljubljana as an example of good practice. According to Kragulj, Parežanin and Jednak (2020), the application of digital technologies and services can significantly help the implementation of the circular economy in Serbia. Bucea-Manea-Țoniș et al. (2021) researched innovation and competitiveness and their relationship to the circular economy, ecoinnovation, and social inclusion, with a focus on Serbia and Romania. However, there is a need to estimate whether the circular economy can be a driver of economic growth in Serbia.

3 Regulatory framework

From an unknown marginal concept created in the 1970s, the circular economy has become an essential strategy in the ambition of the European Green Deal (European Commission, 2020). Until 2019, there have been 7 Directives and 8 Regulations on European level, creating a legal framework for passing out of linear model of production (Friant, Vermeulen and Salomone, 2021).



The European Union's circular economy policy aims to promote the sustainable use of resources by reducing waste, improving the efficiency of resource use, and creating new business opportunities and jobs (European Commission, 2020). Key elements of the policy include:

- Waste reduction and recycling targets: The European Union has set targets to increase the recycling and reuse of waste, reduce landfilling, and increase the use of recycled materials in products.
- Resource efficiency: The European Union promotes the efficient use of resources, with special emphasis on sectors with great circularity potential like ICT and electronics, batteries and vehicles, plastic, textile and construction section.
- Research and innovation: The European union supports research and innovation in the circular economy. For this purpose, which aims to provide consumers with options for reusable packaging and lower the usage of unnecessary packaging.

Many new regulations are planned or being introduced with the aim of achieve green and circular transition. For instance, in order to provide clear labels about environmental effect of product and end *greenwashing*, the process of providing misleading information by companies about their products environmental effect, European Commission has proposed Green Claims Directive in 2023 (European Commission, 2023).

Serbia, as European union candidate state, is in the process of developing its circular economy legislation, and there have been several actions taken towards this goal. In 2020, the Serbian government adopted a National Circular Economy Strategy, which sets out a roadmap for transitioning from linear to more circular production model. The strategy focuses on waste management, resource efficiency, and eco-design, among other areas. (Ministry of Environmental Protection of Republic Serbia, 2020).

There has been a significant increase in circular approach to waste management. Serbia has adopted a Law on Waste Management in 2009 and amended it in 2016, 2018 and 2023 partially aligning its waste management legislation with the EU's Waste Framework Directive and other relevant directives. The law sets out rules for waste collection, transport, treatment, and disposal, as well as requirements for waste prevention and recycling (Ministry of Environmental Protection of Republic Serbia, 2023).

In Industrial policy strategy of the Republic of Serbia from 2021 to 2030, the government addresses the fact that due to linear production is dominating business model, considerable waste in materials and products emerges, leading to the irrational use of resources. In the same strategy, there is a specific objective. 5. *Industry transformation from linear to circular model* in which, as key priorities are seen, education of communities and further harmonizing legislation framework regrading the impletion of circular economy. (Ministry of Economy of Republic of Serbia, 2020)

4 Methodology

In order to estimate whether there is a potential for economic growth by implementing a circular economy in Serbia, several research questions were formulated that were attempted to be answered in this paper:

- What is the state of implementing the circular economy in Serbia and how does it compare to EU countries?
- Is it possible to group countries in Europe regarding the level of implementation of the circular economy, and in which group would Serbia belong?
- What is the relationship between economic growth and the circular economy?

This should provide the answer to our main question: can the circular economy be a driver for economic growth in Serbia?

For this research, circular economy indicators for 27 European Union countries and Serbia were obtained from Eurostat for the period 2014–2021. The circular economy indicators are: recycling rate of municipal waste, circular material use rate, trade in recycling materials, persons employed in circular economy sectors as percentage of total employment, patents related to recycling and secondary raw materials per million people and resource productivity. All of these indicators were used in TwoStep cluster analysis, which was done in SPSS. Also, waste generation per capita was used to see change in waste generation in Europe. Additionally, investment in circular economy was tested but was not significant for cluster analysis. Finally, macroeconomic variables GDP per capita and labour productivity were obtained from this same source.



In order to estimate the economic relationship between GDP growth and indicators of the circular economy, panel data analysis was done in Stata 17.0. Panel data was strongly balanced, which is suitable for panel regression. Three potential models were considered: pooled OLS, fixed effects panel regression and random effects panel regression. For panel regression, three of indicators were used as independent variables: resource productivity (*ResProd*), recycling rate of municipal waste (*RRMW*) and investments in circular economy (*CEInvest*). Also, as independent variable, labour productivity (*LabProd*) was used, as has been documented in paper by Busu and Trica (2019). After using the Hausman test and Lagrangian test, the conclusion was that fixed effects panel regression is the optimal model (Asteriou and Hall, 2011).

5 Results

5.1. Variables

Although the legal framework regarding circular economy has been drastically improved in the last decade, waste generation is still on the rise in the majority of European Union countries. The generation of waste per capita has increased in the European Union from 2014 to 2020 by 9%, as described in Figure 1. The biggest growth has been recorded in the Czech Republic, Belgium, the Slovak Republic, and Austria. Only three countries recorded moderate declines in waste generation: Italy, Sweden, and Bulgaria. Serbia also recorded strong growth in waste generation (42%).

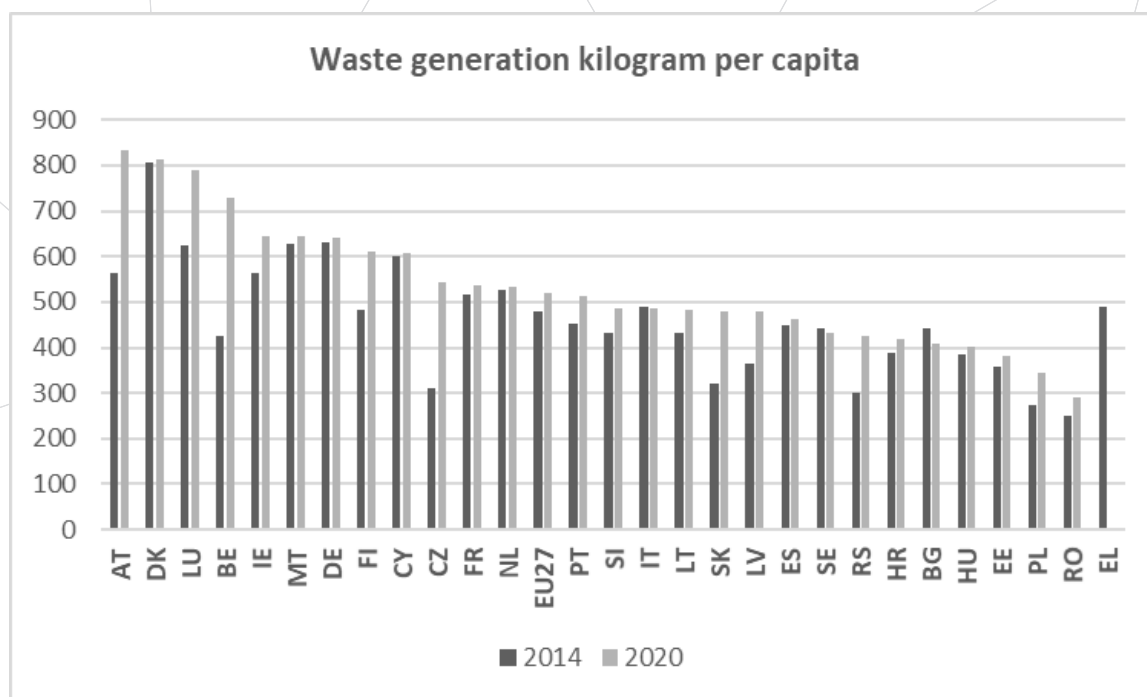


Figure 1. Waste generation per capita, Source: Eurostat (2020)

The circular use of materials rate is calculated as the quotient between the circular use of materials and the total material used. The average European Union circular use of materials rate in 2020 was 11,7% and has increased around 0,5 percentage points from 2014. From Figure 2, it can be seen that in 2020, the EU member states with the highest rates of circular use of materials were the Netherlands (30%), Belgium (21,5%) and Italy (20,6%), while states with the lowest rates were Portugal (2,3%), Ireland (1,7%) and Romania (1,5%). However, some Southern and Eastern European countries have achieved substantial growth, mostly Malta (6,9 p.p.), the Slovak Republic (5,7 p.p.), the Czech Republic (4,8 p.p.) and Estonia (4,7 p.p.). However, nine countries in the EU saw a modest decline, while Poland is an outlier with 5,1 p.p. decrease. Data for Serbia is not available.

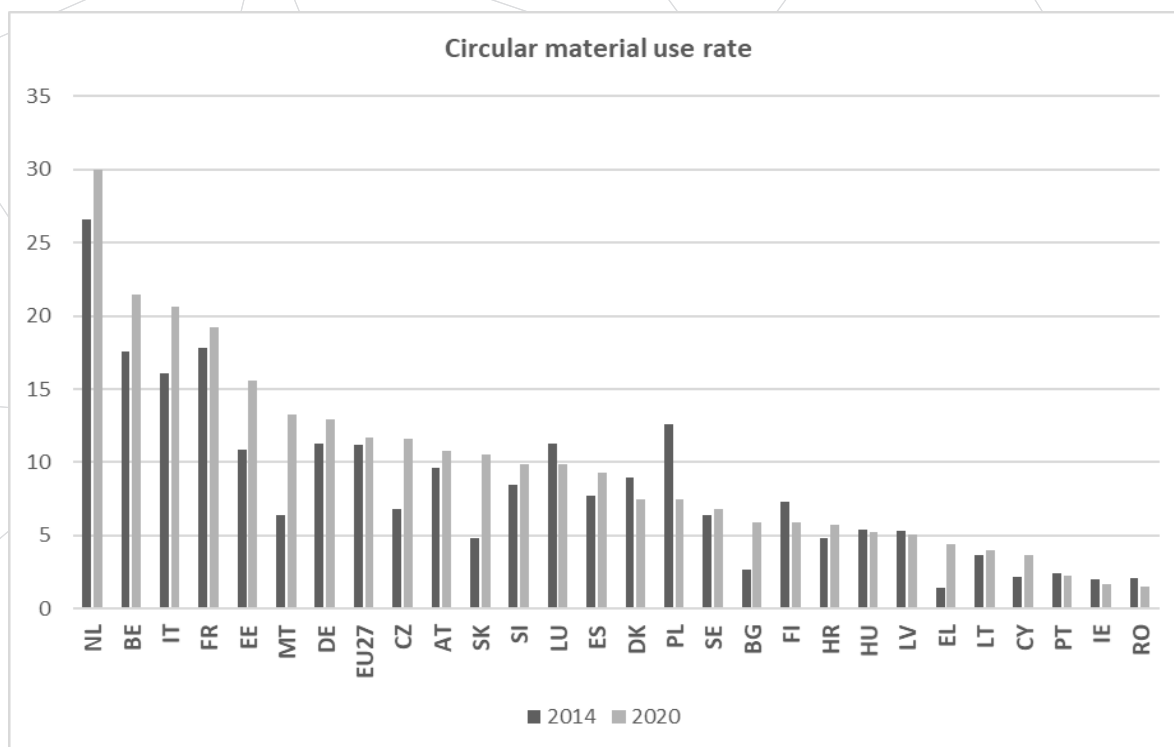


Figure 2. Circular material use, Source: Eurostat (2020)

The recycling rate of municipal waste (RRMW) is defined as municipal waste recycled from total municipal waste generated. The European Union average rate in 2020 was 49.2%, an increase from 5.8 p.p. in 2014. As can be seen from Figure 3, the top-ranked countries by RRMW indicator in 2020 were Germany (70.3%), Bulgaria (65.5%) and Austria (62.3%). Bulgaria and the Slovak Republic have achieved strong growth, 42 and 32 p.p., respectively. Serbia's RRMW was 15.4 in 2020, a major increase from 2014 when the rate was below 1%. Both Romania (11.9%) and Malta (10.9%) ranked lower than Serbia regarding RRMW. Data for 2020 for Greece was not available.

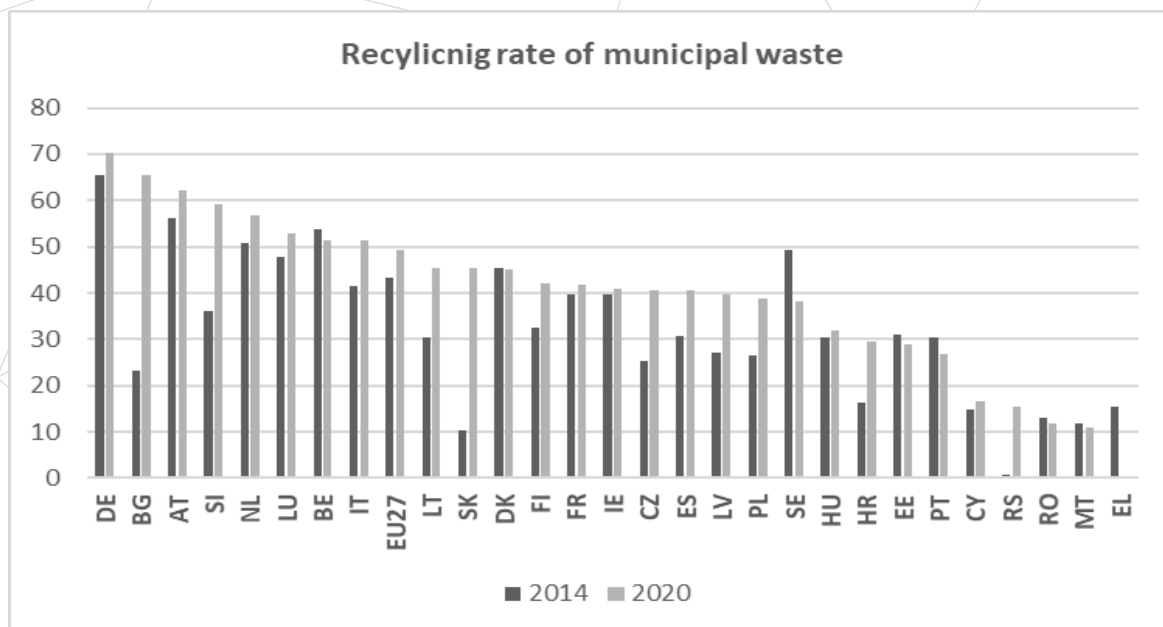


Figure 3. Recycling rate of municipal waste, Source: Eurostat (2020)

Figure 4 gives a description of the number of people employed in circular economy sectors as a percentage of total employment. The European Union average rate was 2.1%, a 0.1 p.p. increase from 2014, while growth in the absolute number of green jobs was 9%. It can be seen that in 2020, Croatia ranks first (3%), followed by Lithuania (2.8%), Latvia and Poland (2.7%), while Luxembourg (0.4%) is in last place.

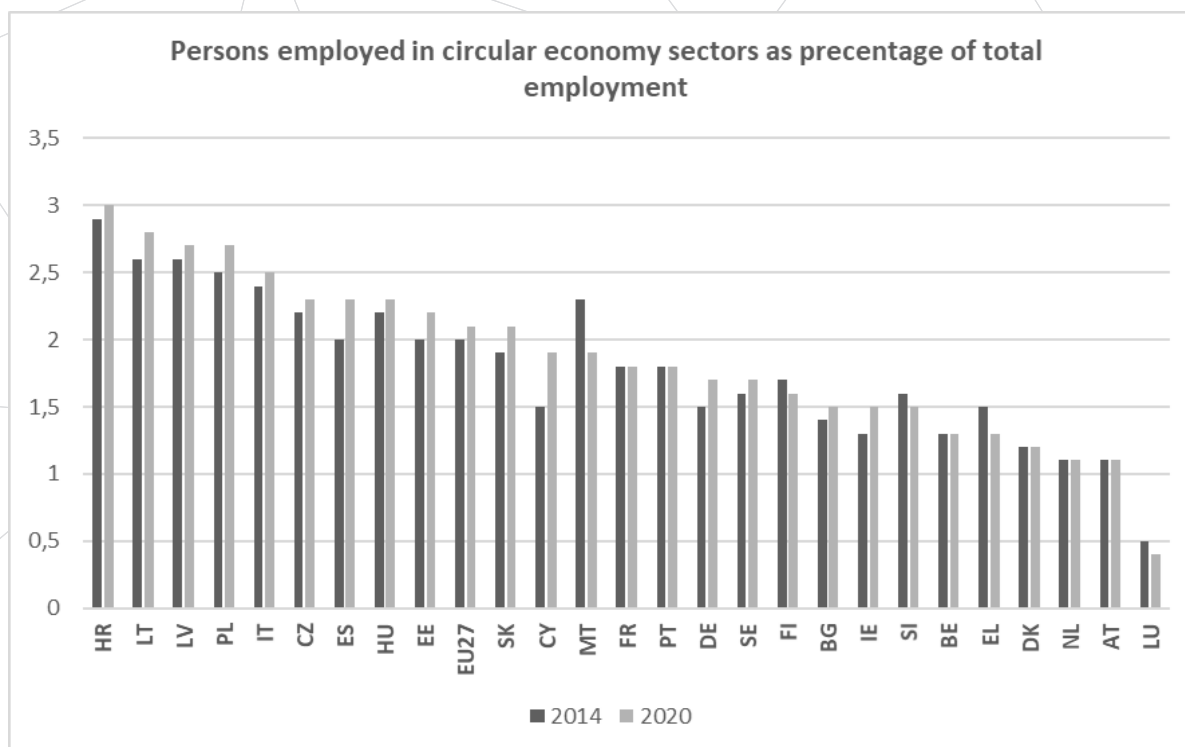


Figure 4. Persons employed in circular economy sectors as percentage of total employment, Source: Eurostat (2020)

Resource productivity is a measure of the total amount of materials directly used by an economy in relation to GDP. The European Union's average resource productivity was constant in this period—around 2 euros per kg. From Figure 5, it can be seen that the EU states with the highest resource productivity were the Netherlands (4.9), Luxembourg (4.3) and Italy (3.4), while the countries with the lowest values of this indicator were the Balkan states: Romania (3.3) and Bulgaria (3.5). Serbia's resource productivity (0.31 euro per kg) is comparable to other Balkan countries that are members of the EU, even though it is lower.

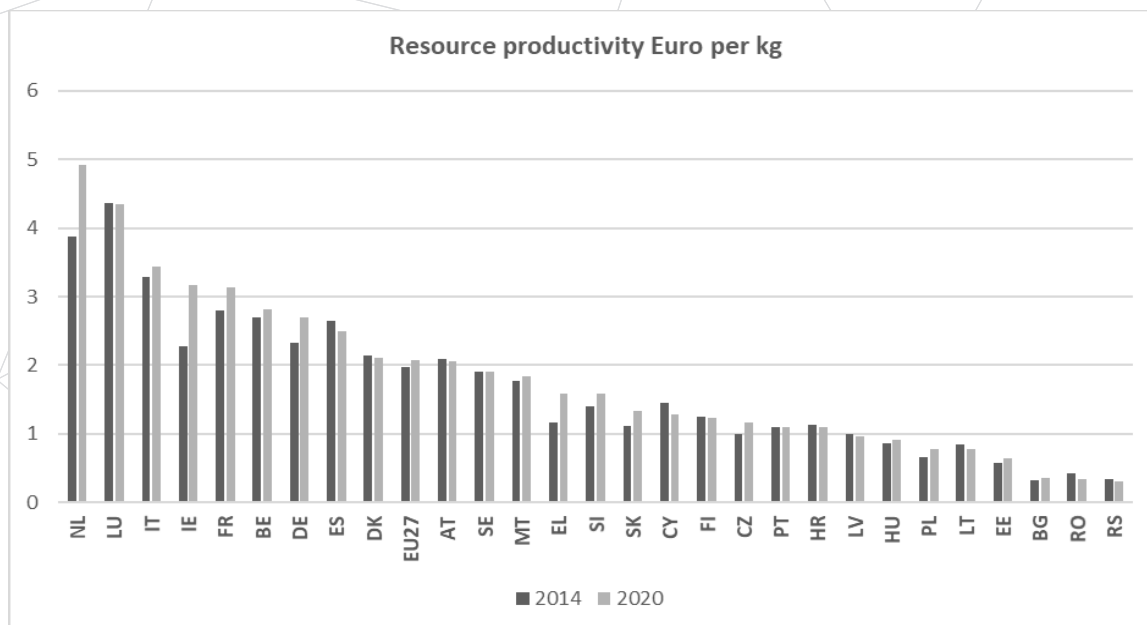


Figure 5. Resource productivity, Source: Eurostat (2020)

Patents related to recycling and secondary raw materials per million people are a circular economy indicator, which represents circular economy innovation capacity in one country. As can be seen in Figure 6, in 2019, Finland was leading in green innovation according to this indicator with 3 patents per million people, followed by Luxembourg and Ireland. A specific issue with the indicator is that for countries with a smaller population, it



is very variable, as can be seen in Figure 6 for Estonia, Luxembourg and Malta in 2014. Only one patent can greatly increase the value of this indicator and give the wrong perception of the innovation capacity of that economy.

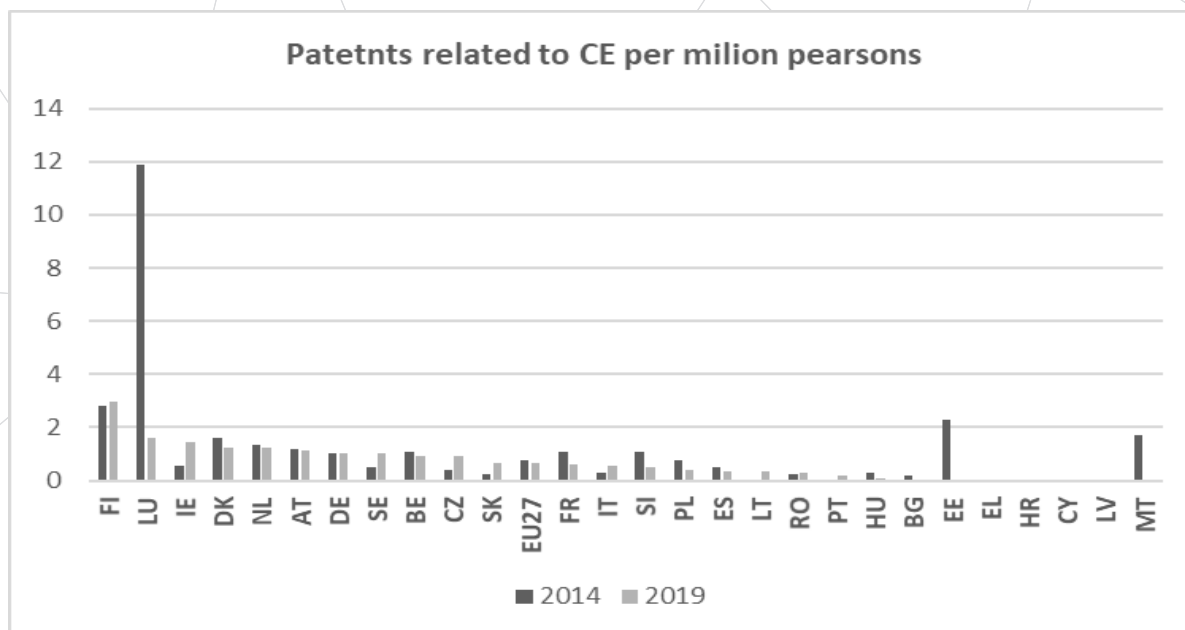


Figure 6. Patterns related to circular economy, Source: Eurostat (2020)

5.2 Cluster analysis

For TwoStep Cluster Analysis, six circular economic indicators have been used as continuous variables: recycling rate of municipal waste, circular material use rate, trade in recycling materials, persons employed in circular economy sectors as percentage of total employment, patents related to recycling and secondary raw materials per million people, and resource productivity. The year 2019 was used as the benchmark year due to the fact that there has not been available data for 2020 and 2021 for all 27 EU countries. According to Akaike's Information Criteria, the optimal number of clusters is two, and they are of similar size. Both clusters are statistically significant.

The first cluster (represented by square points in Figure 7) is made up of the following countries: Belgium, Denmark, Germany, Spain, France, Italy, Luxembourg, the Netherlands, Austria, Finland, Sweden and Slovenia. The following were placed in the second cluster (on Figure 7, represented by round points): Bulgaria, the Czech Republic, Estonia, Ireland, Greece, Croatia, Cyprus, Latvia, Lithuania, Hungary, Malta, Poland, Portugal, Romania and Slovakia. As can be seen on Figure 7, cluster one mostly consists of countries from Western and Northern Europe with exception of Spain and Slovenia, while cluster two from countries of Eastern and Southern Europe.

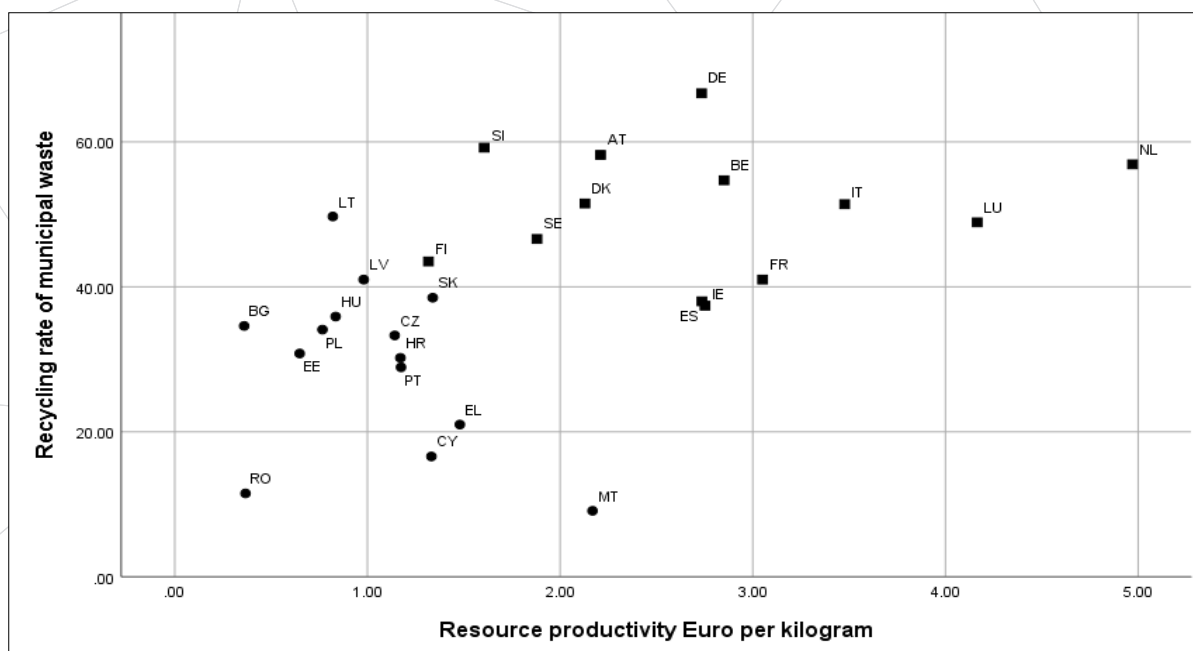


Figure 7. Cluster analysis of countries of the European Union based on circular economic indicators, Eurostat
Source: Data analysis was performed by the authors in SPSS.

As shown in Table 1. countries in cluster 1 a have higher mean value of all circular economic indicators than cluster 2, with the notable exception of persons employed in circular economy sectors as a percentage of total employment.

Table 1. Mean values of two clusters

Mean values	Cluster 1	Cluster 2
Recycling rate of municipal waste	50,31	29,66
Trade in recyclable raw materials Imports intra-EU27 Thousand euro	2.236.588	351.476
Patents related to recycling and secondary raw materials per millions person	1,11	0,21
Circular material use rate	13,15	6,06
Resource productivity Euro per kilogram, chain linked volumes (2015)	2,76	1,04
Percentage of total employment - numerator in full-time equivalent (FTE)	1,54	2,11

Source: Data analysis was performed by the authors in SPSS.

Due to the lack of circular economic indicators for Serbia, it was not included in the cluster analysis. However, according to two circular economic indicators available for Serbia (recycling rate of municipal waste and resource productivity), as well as Eastern European countries, it can be assumed that it is much more similar to countries in cluster 2, especially other Balkan states.

5.3 Regression analysis

As a dependent variable, gross domestic product per capita was used, and investment in circular economy, resource productivity and recycling rate of municipal waste, three widely used circular economy indicators were used as independent variables. Other circular economy indicators, mentioned in methodology section, were tested, however, these three proved most statistically significant. Also, labor productivity was used as an



independent variable, similarly to Busu and Trica (2019) study. According to the unit root test, all five logarithmic values of variables used in the model are stationary and therefore suitable for regression analysis.

Three models were considered in this analysis: fixed effect panel regression, random panel regression and pooled ordinary least squares model (POLS). In order to see if fixed effect or random effect panel regression is more suitable, the Hausman test was used (Figure 8.).

	(1) FixedEfs	(2) RandomEfs
LabProd	1.087*** (0.0460)	1.056*** (0.0511)
ResProd	0.0579 (0.0318)	0.129*** (0.0339)
CEInvest	0.0523*** (0.00872)	0.0530*** (0.00958)
RRMW	0.0442*** (0.0122)	0.0414** (0.0136)
_cons	4.418*** (0.193)	4.542*** (0.225)
N	209	209
r2	0.860	
r2_o	0.247	0.442
r2_b	0.273	0.473
r2_w	0.860	0.856
sigma_u	0.569	0.317
sigma_e	0.0255	0.0255
rho	0.998	0.994

Standard errors in parentheses

* p<0.05, ** p<0.01, *** p<0.001

Figure 8. Fixed and Random effect panel regression used for Hausman test

Source: Data analysis was performed by the authors in Stata 17.0.

Because the probability of Chi-squared is less than 0.05%, it can be concluded that the fixed effect model of panel regression is more appropriate for this data set. Results are shown in Figure 9.

	Coefficients			
	(b)	(B)	(b-B)	sqrt(diag(V_b-V_B))
	FixedEffects	RandomEfs	Difference	Std. err.
LabProd	1.087131	1.056032	.0310991	.0070165
ResProd	.0579408	.1288367	-.070896	.0108908
CEInvest	.0522856	.0530341	-.0007485	.0018985
RRMW	.0441552	.0413734	.0027818	.0011093

b = Consistent under H0 and Ha; obtained from **xtreg**.

B = Inconsistent under Ha, efficient under H0; obtained from **xtreg**.

Test of H0: Difference in coefficients not systematic

$$\text{chi2}(4) = (b-B)'[(V_b-V_B)^{-1}](b-B) = 44.56$$

Prob > chi2 = 0.0000

Figure 9. Hausman test

Source: Data analysis was performed by the authors in Stata 17.0.

Secondly, random effects were tested by the Langrangian multiplier. Results are shown in Figure 10, because of which we reject the POLS model. After rejecting POLS and random effect panel regression, analysis shows that fixed effect panel regression is most suitable.



Breusch and Pagan Lagrangian multiplier test for random effects

$$\text{GDP}[c_number, t] = Xb + u[c_number] + e[c_number, t]$$

Estimated results:

	Var	SD = sqrt(Var)
GDP	.3700778	.6083402
e	.0006511	.0255164
u	.1005413	.3170825

Test: $\text{Var}(u) = 0$

chibar2(01) = 654.77
Prob > chibar2 = 0.0000

Figure 10. Lagrangian test

Source: Data analysis was performed by the authors in Stata 17.0.

The next step was to test heteroscedasticity in fixed effect panel regression with Modified Wald test for groupwise heteroscedasticity. According to the results of Modified Wald test, the probability of Chi-squared is less than 0.05%. Because of that, we reject H_0 and conclude that there is heteroscedasticity problem. In order to deal with these issues, robust standard errors were used to see if the parameters were statistically significant.

As demonstrated in Figure 11, the greatest effect on the rate of economic growth was that of the rate of growth of real labour productivity ($\beta = 1,08$), then the rate of growth of circular economic investment ($\beta = 0.05$), and at the end, the rate of growth of RRMW ($\beta = 0,04$). Resource productivity according the results is not statistical significant. Since the value of R-squared is 0.2472, we emphasize that 24.72% of the variability of the growth GDP p.c. variable is determined by the exogenous factors of the model.

Fixed-effects (within) regression
 Group variable: **c_number**

Number of obs = **209**
 Number of groups = **27**

R-squared:

Within = **0.8603**
 Between = **0.2726**
 Overall = **0.2472**

Obs per group:

min = **6**
 avg = **7.7**
 max = **8**

$\text{corr}(u_i, Xb) = \mathbf{0.3214}$

F(4,26) = 184.28
Prob > F = 0.0000

(Std. err. adjusted for 27 clusters in **c_number**)

GDP	Coefficient	Robust std. err.	t	P> t	[95% conf. interval]	
LabProd	1.087131	.0560268	19.40	0.000	.9719661	1.202296
ResProd	.0579408	.0592539	0.98	0.337	-.0638573	.1797389
CEInvest	.0522856	.0164494	3.18	0.004	.0184735	.0860977
RRMW	.0441552	.0205636	2.15	0.041	.0018861	.0864243
_cons	4.417841	.2620078	16.86	0.000	3.879276	4.956406
sigma_u	.5693441					
sigma_e	.02551636					
rho	.99799545	(fraction of variance due to u_i)				

Figure 11. Fixed effect panel regression

Source: Data analysis was performed by the author in Stata 17.0.



$$GDP = 4,41 + 1,08 LabProd + 0,05 CEInvest + 0,04 RRMW$$

Where is *GDP* – Gross domestic product per capita, *LabProd* – Labour productivity, *CEInvest* – Investment in circular economy and *RRMW* – rate of recycling of municipal waste.

The beta parameters show that both increases in the rate of recycling municipal waste and investment in a circular economy have positive effects on GDP growth, although the value of the beta parameter for labor productivity is much higher than for CE indicators. According to panel regression from this analysis, a 1 p.p. increase in labour productivity will increase GDP growth by 1,08 p.p., much higher than an increase in investment in a circular economy and RRMW.

6 Conclusion

The findings correspond with the study by Busu and Trica (2019), which indicate that the implementation of the circular economy in the European Union had a positive effect on economic growth in the period from 2010 to 2017. Also, these results build on existing evidence from this research that, specifically, the rate of recycling of municipal waste and investments in the circular economy have increased economic growth. Contrary to the same research and paper by Trica, Banacu and Busu (2019), this analysis does not provide evidence that resource productivity has a positive effect on GDP growth.

The main issue for these papers is the lack of comparable data for Serbia, which is an obstacle in estimating Serbia's position in how Serbia ranks alongside European Union countries and cannot be included in the panel regression. Furthermore, the predictive function of the model is also limited due to the use of robust standard errors. Further research on this topic should include a dynamic perspective on analysis, which could be more suitable for econometric problems. Also, using national statistical datasets can provide further insight into the relationship between economic growth and the circular economy.

Although the implementation of a circular economy is high on the policy agenda in the European Union, waste generation per capita has increased from 2014 to 2021. There is also a difference between the level of implementation of the circular economy in Western and Northern European countries on the one hand and Eastern and Southern European countries on the other, with the latter lagging behind in the transition to the circular economy. Due to a lack of comparable data, it is not feasible to estimate which group Serbia belongs to. However, with few available indicators and owing to Serbia's geographic position, it can be assumed that Serbia has many more similarities with Eastern and Southern countries.

According to panel data analysis, there is evidence that increases in circular economy investments and RRMW will have a positive effect on GDP growth. However, according to the analysis, the coefficients for circular economy indicators are much smaller than labor productivity. The implementation of the circular economy has the potential to accelerate economic growth; however, there is not enough evidence to claim that it can be the main driver of economic growth in Serbia.

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