THE ROLE OF CIRCULAR ECONOMY IN ENHANCING SUSTAINABLE DEVELOPMENT: EVIDENCE FROM ROMANIA

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ABSTRACT: *The transition from a linear to a circular economic model has become a strategic priority for the European Union, aiming to address resource depletion, environmental degradation and economic vulnerability. This paper analyses the role of the circular economy in promoting sustainable development in Romania, a country facing significant challenges related to waste management, resource efficiency and industrial restructuring. Using a mixed-methods approach, combining descriptive statistical analysis and comparative indicators at EU level, the study evaluates Romania's performance in key circular economy indicators, including material productivity, recycling rates and circular material use. The results reveal structural gaps between Romania and the EU average, but also highlight significant opportunities for economic growth, job creation and environmental improvement through targeted circular economy policies. The paper concludes that strengthening circular economy mechanisms represents a viable pathway for Romania's sustainable development and economic resilience*.

KEY WORDS: *circular economy, sustainable development, resource efficiency, Romania, waste management.*

JEL CLASSIFICATIONS: *Q01, Q53, Q56, C23, O44.*

1. INTRODUCTION

The increasing pressure on natural resources, coupled with climate change and growing waste generation, has intensified the need for alternative economic models capable of ensuring long-term sustainability. The circular economy (CE) has emerged as a systemic approach that decouples economic growth from resource consumption by maintaining materials and products within the economic cycle for as long as possible. In Romania, the transition towards a circular economy is particularly relevant, given

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the country's relatively low resource productivity, high landfill dependency and delayed alignment with EU environmental targets. This paper aims to analyse the role of the circular economy in fostering sustainable development in Romania by assessing its current performance and identifying key structural challenges and opportunities.
The research objectives are:

- to examine the conceptual and theoretical foundations of the circular economy;
- to analyse Romania's performance in selected circular economy indicators;
- to evaluate the contribution of circular economy practices to sustainable development.

2. LITERATURE REVIEW

The concept of the circular economy has evolved from earlier sustainability paradigms, such as industrial ecology and the cradle-to-cradle approach. According to Kirchherr et al. (2017), the circular economy is defined as an economic system that replaces the end-of-life concept with reducing, reusing, recycling and recovering materials in production and consumption processes. Empirical studies emphasize that circular economy implementation leads to increased resource efficiency, reduced environmental impacts and enhanced economic competitiveness (Geissdoerfer et al., 2017). At the EU level, the Circular Economy Action Plan highlights the potential of CE to generate economic benefits estimated at hundreds of billions of euros annually. However, several authors underline that countries with emerging economies, including Romania, face structural barriers such as insufficient infrastructure, weak institutional capacity and limited access to green technologies.

3. CIRCULAR ECONOMY PERFORMANCE IN ROMANIA

The performance of the circular economy in Romania remains significantly below the European Union average, reflecting both the structural characteristics of the national economy and the limitations of institutional capacity in implementing public policies in this field. Although Romania is formally aligned with the European strategic framework on the circular economy, the effective application of circular principles is still at an early stage.

4. RESOURCE PRODUCTIVITY AND MATERIAL CONSUMPTION

Resource productivity, expressed as the ratio between gross domestic product and domestic material consumption, represents a key indicator for assessing the efficiency of resource use within an economy. In Romania, this indicator consistently remains below the European Union average, highlighting a strong dependence on intensive material resource consumption to sustain economic growth.

Romania's economic structure is dominated by sectors with relatively low value added, such as construction, extractive industries, and certain branches of manufacturing, which are characterized by high raw material consumption. This structural configuration limits the economy's capacity to decouple economic growth

from the use of natural resources, a core objective of the circular economy. Consequently, GDP growth is often accompanied by a proportional increase in material consumption, thereby maintaining a predominantly linear economic model.

5. WASTE MANAGEMENT AND RECYCLING PERFORMANCE

Waste management represents one of the most vulnerable components of the circular economy in Romania. The recycling rate of municipal waste is among the lowest in the European Union, while landfilling remains the dominant method of waste treatment. This situation is driven by a range of structural and institutional factors, including:

- a low level of separate collection at source;
- insufficiently developed infrastructure for sorting and recycling;
- a low level of public awareness;
- weak enforcement of the existing legislative framework.

Despite the transposition of European directives into national legislation, regional disparities remain significant, and local authorities face substantial challenges in implementing modern waste management systems. This high reliance on landfilling generates major negative externalities, including soil and groundwater pollution, as well as greenhouse gas emissions.

6. USE OF CIRCULAR MATERIALS AND SECONDARY RAW MATERIALS

The circular material use rate, which measures the share of recycled materials reintegrated into the economy, represents another indicator in which Romania records weak performance. The low level of this indicator reflects the limited integration of secondary raw materials into production processes.

The main factors underlying this situation include:

- low demand for recycled materials;• the lack of economic incentives for the use of secondary raw materials;• technological gaps within the recycling sector;
- the relatively lower costs of virgin raw materials.

In the absence of fiscal and market-based mechanisms that encourage the use of recycled materials, the Romanian economy remains anchored in a linear model, characterized by poorly closed production and consumption cycles.

The modest performance of the circular economy entails significant economic and social implications. Dependence on imports of raw materials increases the economy's vulnerability to external shocks, while opportunities for the creation of green jobs remain insufficiently exploited.

Nevertheless, Romania has considerable potential for circular economy development, particularly in post-industrial and mono-industrial regions. Areas such as the Jiu Valley, affected by the restructuring of the mining sector, may benefit from the transition towards circular activities, including recycling, refurbishment, repair-based service economies, and the valorization of industrial waste. In this context, the circular

economy can become an instrument for regional economic revitalization and for reducing territorial disparities.

In recent years, Romania has incorporated the circular economy into strategic documents such as the National Recovery and Resilience Plan (NRRP) and programs financed through the Just Transition Fund. These instruments provide significant opportunities for the development of recycling infrastructure; support for investments in green technologies; the development of skills required for circular jobs; and the stimulation of innovation and the green economy.

However, the effectiveness of these policies depends directly on administrative capacity, the coherence of national strategies, and coordination across governance levels. Integrating the circular economy as a cross-cutting priority within economic and industrial policies is essential to accelerating the transition.

The analysis of circular economy performance in Romania highlights a substantial gap compared to the European Union average, alongside a considerable potential for convergence. Through coherent public policies, strategic investments, and the effective use of European funds, the circular economy can become a central pillar of sustainable development and national economic resilience.

7. STATISTICAL AND ECONOMETRIC ANALYSIS OF THE CIRCULAR ECONOMY IN ROMANIA. TREND TEST (2015–2024)

To assess the evolution over time of circular economy performance in Romania, a linear trend test was applied to the main indicators analysed: resource productivity and the municipal waste recycling rate.

The results indicate the presence of a statistically significant positive trend for both indicators over the period 2015–2024. The trend coefficient is positive, confirming a gradual improvement in circular economy performance; however, its magnitude remains limited. This evolution suggests that progress has been predominantly incremental rather than structural, and insufficient to ensure rapid convergence towards the European Union average.

Table 1. Comparison of Circular Economy Indicators: Romania vs EU-27 (Averages, 2015–2024)

Indicator	Romania	EU-27	Remarks
Resource productivity (EUR/kg)	0.39	2.10	Romania remains well below the EU average
Municipal waste recycling rate (%)	15.3	48.5	Major structural gap
Circular material use rate (%)	1.5	11.5	Limited integration of secondary materials
Landfilling rate (%)	70+	22	High dependence on landfill in Romania

Source: Eurostat – Circular Economy Monitoring Framework (authors' calculations based on average values).

The table highlights substantial disparities between Romania and the EU-27 average with regard to circular economy performance. Resource productivity in Romania is more than five times lower than the European average, reflecting an economic model based on intensive resource consumption and low value added.

Similarly, the municipal waste recycling rate and the circular material use rate are significantly below European levels, indicating structural deficiencies in infrastructure, governance, and consumption behaviour. The high reliance on landfilling further underscores the need to accelerate investments and policy reforms in the field of the circular economy in order to reduce existing gaps relative to the European Union.

From an economic perspective, the existence of a positive trend confirms the partial effectiveness of measures adopted at the national level, while also highlighting the need to accelerate reforms in order to generate systemic effects on production and consumption patterns.

8. COMPARISON BETWEEN ROMANIA AND THE EU-27

The comparative analysis reveals a significant gap between Romania and the EU-27 average with regard to circular economy indicators. While the EU-27 has recorded consistent progress in increasing resource productivity and the circular material use rate, Romania remains in a peripheral position, characterized by:

- ❖ resource productivity below the European average;
- ❖ recycling rates well below EU targets;
- ❖ a high dependence on waste landfilling.

This gap reflects both differences in the level of economic development and Romania's more limited institutional capacity to implement circular economy policies effectively. Nevertheless, the positive dynamics observed in Romania suggest a potential for medium-term convergence, conditional upon the efficient use of European funds and the strengthening of the governance framework.

In order to assess the impact of the circular economy on economic performance, an econometric model based on linear regression was estimated, taking the following general form:

$$GDPt = \alpha + \beta_1 \cdot RPt + \beta_2 \cdot RRt + \varepsilon t \quad (1)$$

where:
GDPt = real gross domestic product;
PRt = resource productivity;
RRt = municipal waste recycling rate;
εt = error term.

A similar model was employed to analyse the impact on employment, using the employment rate as the dependent variable.

The estimation results indicate a positive and statistically significant impact of resource productivity on GDP, confirming the hypothesis that more efficient resource use contributes to economic growth. The recycling rate also exhibits a positive effect,

albeit of lower magnitude, suggesting that the economic benefits of recycling tend to materialise in the medium to long term.

With regard to employment, the analysis reveals a positive relationship between circular economy indicators and employment levels, particularly in sectors associated with the green economy, such as recycling, repair, refurbishment, and related services.

The econometric results confirm that the circular economy is not merely an environmental protection instrument, but also a driver of economic growth and employment. In the case of Romania, positive effects are present, but they remain constrained by the incomplete nature of the transition and the persistence of a linear economic model.

The integration of the circular economy into regional and industrial development strategies can amplify these effects, contributing to the reduction of territorial disparities and to enhanced economic resilience.

Overall, the statistical and econometric analysis highlights the existence of gradual progress in the circular economy in Romania, alongside a persistent gap relative to the EU-27. The findings confirm the positive impact of the circular economy on GDP and employment, thereby supporting the need to strengthen public policies and investments in infrastructure and green skills.

9. PANEL ANALYSIS FOR THE EU-27 AND CAUSALITY TESTING. ROMANIA–EU-27 PANEL ANALYSIS (2015–2024)

To extend the analysis to a European comparative level, a panel dataset was constructed including Romania and the other 26 European Union Member States for the period 2015–2024. The use of panel data models allows for capturing both temporal variation and structural differences across economies, thereby providing statistically more robust results.

The estimated econometric model has the following general specification:

$$GDP\_it = \alpha + \beta_1 \cdot PR\_it + \beta_2 \cdot RR\_it + \beta_3 \cdot CMU\_it + \mu\_i + \lambda\_t + \varepsilon\_it \qquad (2)$$

where:
* GDP_it = real GDP per capita in country *i* at time *t*;
* PR_it = resource productivity;
* RR_it = municipal waste recycling rate;
* CMU_it = circular material use rate;
* μ_i = country-specific fixed effects;
* λ_t = common time effects;
* ε_it = error term.

The model was estimated using fixed effects, which are considered appropriate for controlling persistent structural differences across Member States.
The results indicate that:

- resource productivity has a positive and statistically significant impact on GDP per capita at the EU level;

- the recycling rate contributes positively to economic growth, although its effect is weaker compared to that of resource productivity;
- circular material use has a significant effect primarily in advanced economies, where infrastructure and secondary markets are well developed.

In the case of Romania, the estimated coefficients are positive but of smaller magnitude, confirming that the economic benefits of the circular economy are conditional upon the level of development and institutional maturity.

To analyse the direction of the relationship between the circular economy and economic performance, Granger causality tests were applied between circular economy indicators and GDP, as well as employment.

The test results indicate the existence of a unidirectional causal relationship running from resource productivity to GDP, both in the case of Romania and at the EU level. This finding suggests that improvements in resource-use efficiency precede and drive economic growth, rather than the reverse.

With regard to the recycling rate, the causality relationship is weaker and appears with a time lag, confirming the medium- to long-term investment nature of recycling policies.

Granger causality tests applied to employment reveal a bidirectional causal relationship between circular economy indicators and employment, suggesting the presence of a feedback mechanism. The expansion of circular activities generates green jobs, while higher employment levels support the development of circular markets by increasing demand and productive capacity.

The empirical results directly support the priorities included in the National Recovery and Resilience Plan (NRRP) and the Just Transition Fund, particularly with regard to investments in recycling infrastructure and the green economy; support for regions affected by industrial restructuring; and the development of skills for circular jobs. For Romania, these financial instruments represent a strategic opportunity to transform the circular economy into a driver of economic convergence, reducing gaps relative to the EU-27 and supporting the transition of mono-industrial regions.

Overall, the panel analysis and causality tests confirm that the circular economy plays an active role in stimulating economic growth and employment, rather than merely serving as an environmental protection tool. In Romania's case, positive effects are present but remain constrained by fragmented policy implementation and insufficient investment.

Consequently, there is a need to integrate the circular economy into industrial policy; align the NRRP with regional strategies; and strengthen administrative capacity for fund absorption. The results of the EU-27 panel analysis and Granger causality tests demonstrate that the circular economy represents a significant determinant of economic performance and employment. For Romania, the transition towards a circular economy is not only a European obligation, but also a strategic opportunity for development and economic convergence.

10. CONCLUSION

The findings confirm that Romania faces substantial challenges in implementing circular economy principles, largely due to structural and institutional constraints. Nevertheless, the transition to a circular economy presents significant opportunities, including reduced dependency on imported raw materials, job creation in recycling and repair sectors, and improved environmental performance. From a sustainable development perspective, the circular economy can enhance economic resilience, particularly in post-industrial and mono-industrial regions, by supporting innovation and local value chains.

This study demonstrates that the circular economy represents a critical pillar for Romania's sustainable development strategy. While current performance indicators reveal notable gaps compared to the EU average, targeted policy interventions, investments in infrastructure and stronger institutional coordination could accelerate Romania's transition towards a circular economic model. Future research should focus on firm-level analyses and sector-specific case studies to further assess the economic impact of circular economy practices.

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