

Leveraging Sustainable Development Goals for Advancing the Consumption, Production and Economic Growth in the Visegrad Group Countries

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Abstract: Consumption and production practices have profound environmental impacts. Embracing sustainable consumption and production methods is essential for efficient resource utilization, respecting ecological boundaries, and alleviating pressure on natural resources. This approach not only fosters overall well-being but also ensures the preservation of a healthy environment and resources for future generations. Sustainable Development Goal 12 (SDG 12) offers crucial metrics for assessing progress in these areas. Within the European Union, monitoring SDG 12 emphasizes decoupling environmental impacts from economic growth and focuses on trends in energy consumption and waste management. This work investigates the relationship between economic development, indicated by Real GDP per capita, and sustainable production and consumption, represented by the Circular Material Use Rate, in the Visegrad Group (V4) countries: Slovakia, the Czech Republic, Hungary and Poland. Additionally, it examines the connections between these indicators and the objectives of SDG 8 'Decent Work and Economic Growth' and SDG 12 'Responsible Consumption and Production'. Through regression analysis, the study identifies a significant positive correlation between Real GDP per capita and the Circular Material Use Rate, particularly in the Czech Republic.

Keywords: Sustainability; Sustainable development; Sustainable production

1 Introduction

For economic growth to achieve sustainability, it must be complemented by enhancements in eco-efficiency, proactive climate initiatives, and resilient frameworks, together with vibrant labor market policies and efforts to foster social

inclusion. These steps are vital to prevent adverse effects on the natural environment and to avoid undermining the social cohesion of European communities. Consequently, sustainable economic growth is not only about enhancing economic indicators but also involves creating equitable employment opportunities and improving the working conditions for the workforce.

Since the conclusion of World War II, the escalation in living standards and quality of life across Europe has been driven by increased income, production, and consumption. These factors have traditionally been associated with intensified resource extraction and escalated pressures on natural capital – encompassing air, water, land, and biodiversity – and the climate. Living on a planet with limited and interconnected resources means that the consumption rate of these resources significantly influences current prosperity and has enduring consequences for future generations. It is therefore crucial for the European Union to uncouple the links between economic growth and living standards improvements, from resource consumption and its associated negative environmental impacts. A key strategy in this effort is to enhance the circularity of materials within the economy, which helps to minimize the need for fresh resource extraction and reduces the volume of waste directed to landfills.

Over the past three decades, sustainable development has emerged as a leading area of research, primarily drawing from an ecological standpoint as noted by Rybarova *et al.* [1]. The increasing consciousness and concern in the Western world regarding pollution reduction and environmental conservation have been prominently voiced by the academic community, public opinion, and policymakers, as highlighted by Nabukalu, Asamani, and Nabyonga-Orem [2]. Nonetheless, sustainable development effectively integrates ecological, social, and economic perspectives to foster holistic social evolution.



Figure 1

Sustainable development goals – overview

Sustainable development goals have long been central to European policy, deeply embedded within European Treaties and integrated across broad-ranging projects, sector-specific policies, and initiatives [3-5]. The introduction of the 2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals (SDGs) by the United Nations in September 2015 has revitalized global efforts toward achieving sustainable development [6]. These goals, as shown in Figure 1, are now fundamental to European Union policy and highlight the focus areas pertinent to this research.

1.1 Sustainable Development Goals and Their Impact on Europe

The SDGs were designed as a universal call to action to end poverty, protect the planet, and ensure that all people enjoy peace and prosperity by 2030. Unlike their predecessors, the Millennium Development Goals (MDGs), which were more focused on developing countries, the SDGs are universal and applicable to all nations, including those in Europe [7].

Europe has adopted the SDGs as part of its broader agenda for sustainable development, integrating them into its policies at both the European Union (EU) and national levels. The European Commission has played a crucial role in promoting and monitoring the implementation of the SDGs across member states [8]. The SDGs cover a broad range of issues, but for Europe, key areas of focus have included climate action, responsible consumption and production, sustainable cities and communities, and partnerships for the goals [9] [10].

The SDGs have significantly influenced European policies and strategies, particularly in areas such as climate change, economic development, and social inclusion [7, 11, 12]. The European Green Deal, for instance, is a landmark initiative that aligns closely with the SDGs, aiming to make Europe the first climate-neutral continent by 2050. This initiative reflects SDG 13 (Climate Action) and integrates elements of SDG 7 (Affordable and Clean Energy), SDG 11 (Sustainable Cities and Communities), and SDG 12 (Responsible Consumption and Production) [13].

Moreover, the European Semester, a framework for coordinating economic policies across the EU, has integrated the SDGs into its country-specific recommendations. This integration helps ensure that economic growth is inclusive and sustainable, aligning with SDG 8 (Decent Work and Economic Growth) and SDG 10 (Reduced Inequalities) [14]. The EU's external policies have also been shaped by the SDGs, particularly in terms of development cooperation and trade [15]. The EU has been a leading advocate for incorporating SDGs into trade agreements, promoting sustainable development through economic partnerships with countries around the world [16].

Europe has made significant progress in certain areas of the SDGs, particularly in environmental sustainability and social inclusion. For example, the EU has seen substantial reductions in greenhouse gas emissions, improved energy efficiency, and increased use of renewable energy sources, aligning with the targets of SDG 13 (Climate Action) and SDG 7 (Affordable and Clean Energy) [17].

Despite these successes, significant challenges remain in fully realizing the SDGs across Europe. One of the main challenges is the uneven progress between and within member states. While some countries, such as Sweden and Denmark, are leading in SDG implementation, others lag behind, particularly in areas related to inequality, sustainable consumption, and environmental protection (Eurostat, 2020).

Economic disparities between regions have also posed challenges to achieving the SDGs. For instance, Eastern and Southern European countries have faced greater difficulties in reducing unemployment and poverty, and in promoting sustainable industrial practices (SDG 9: Industry, Innovation, and Infrastructure) [18] [19].

Furthermore, the COVID-19 pandemic has exacerbated existing challenges, particularly in achieving goals related to health, education, and economic growth. The pandemic has highlighted the need for stronger resilience and preparedness, emphasizing the importance of SDG 3 (Good Health and Well-being) and SDG 8 (Decent Work and Economic Growth) [20].

1.2 Sustainable Development Goals and Their Impact on V4 Countries

The Sustainable Development Goals (SDGs) have been integral to shaping the economic and social development strategies of countries globally, and the Visegrád Group (V4), consisting of Poland, Hungary, the Czech Republic, and Slovakia, is no exception. As these nations continue to integrate the SDGs into their national policies, their economic growth patterns have been notably influenced. This literature review examines the impact of SDGs on economic growth in the V4 countries, highlighting various studies that explore the intersection of sustainable development and economic performance.

One of the significant drivers of economic growth in the V4 countries is foreign direct investment (FDI). According to research by Fifeková and Nemcová [21], FDI has played a pivotal role in accelerating technological advancements and structural changes within these economies. The study suggests that FDI not only enhances productivity but also fosters innovation, which is crucial for achieving SDG 9, focusing on industry, innovation, and infrastructure. The positive impact of FDI is reflected in improved technological performance and export capabilities, further contributing to narrowing the economic gap between the V4 countries and more developed EU nations [21].

In addition to FDI, the relationship between economic growth and quality of life has been explored in several studies. Rajnoha et al. [22] examined the connection between GDP growth and various quality of life indicators in the V4 countries and Austria. Their findings indicate that economic growth has a positive effect on quality of life, aligning with SDG 8, which promotes inclusive and sustainable economic growth. The study reveals that many life quality indicators in the V4 countries are comparable to or even better than the EU average, highlighting the countries' progress in improving living standards alongside economic growth. However, the study also points out a sustainable development gap when compared to Austria, a more developed benchmark country [22].

Urbanization has emerged as another critical factor influencing sustainable economic growth. Kwiliński et al. [23] explored the effects of urbanization on green growth within the context of the SDGs. The study focused on how rapid urbanization in the V4 countries has contributed to economic growth, but at the same time, has raised concerns about environmental sustainability. The findings indicate that urbanization, while driving economic development, can lead to excessive resource consumption and environmental degradation, thereby threatening the achievement of SDG 11 (Sustainable Cities and Communities) and SDG 13 (Climate Action). To mitigate these effects, the study recommends implementing structural reforms and investing in technological modernization to promote green growth [23] [24].

Another area of concern is the balance between economic and social development. Csath [25] argues that while economic growth, as measured by GDP, has been a priority in the V4 countries, social conditions have not improved at the same rate. The study emphasizes that achieving a balance between economic and social development is crucial for sustainable growth and for avoiding the middle-income trap. This analysis underscores the need for policy interventions that align with SDG 10 (Reduced Inequality) to ensure that the benefits of economic growth are distributed more equitably across society [25] [26].

The link between competitiveness and sustainable economic performance has also been studied in the context of the V4 countries. Rajnoha and Lesníková [27] examined how the Global Competitiveness Index (GCI) relates to economic growth and sustainability in the region. Their research shows that higher levels of competitiveness are associated with improved economic performance, which in turn positively impacts sustainability indicators. This finding supports the idea that enhancing competitiveness through innovation and R&D can lead to better alignment with SDG 8, ultimately fostering sustainable economic growth [27].

2 Materials and Methods

In this section, we delineate the primary research objective, sub-goals, research focus, and the methodology utilized in this research paper.

The primary objective of this paper is to explore the interrelationship between economic development, as indicated by Real GDP per capita, and sustainable production and consumption, as measured by the Circular Material Use Rate, within the V4 countries (Slovakia, Czech Republic, Hungary, and Poland). This analysis also aims to elucidate the connection between these indicators and the objectives of SDG 8 'Decent Work and Economic Growth' and SDG 12 'Responsible Consumption and Production'. The following research questions have been formulated:

- **Research question 1:** Does a relationship exist between economic growth, as indicated by Real GDP per capita, and sustainable production and consumption measures, as shown by the Circular Material Use Rate, in Slovakia?
- **Research question 2:** Does a relationship exist between economic growth, as indicated by Real GDP per capita, and sustainable production and consumption measures, as shown by the Circular Material Use Rate, in the Czech Republic?
- **Research question 3:** Does a relationship exist between economic growth, as indicated by Real GDP per capita, and sustainable production and consumption measures, as shown by the Circular Material Use Rate, in Hungary?
- **Research question 4:** Does a relationship exist between economic growth, as indicated by Real GDP per capita, and sustainable production and consumption measures, as shown by the Circular Material Use Rate, in Poland?

To address the main aim, we have identified several specific research objectives: to detail the selected indicators of SDG 8 and SDG 12, to analyze the evolution of these indicators, to compare these indicators across the V4 countries, and to evaluate the factors influencing their development.

The European Union tracks sustainable development through 17 distinct goals. SDG 8 promotes sustained economic growth and higher productivity and innovation levels, targeting full and productive employment and decent work for all by 2030. SDG 12 advocates for the adoption of sustainable practices and sustainability reporting by enterprises, enhancement of sustainable procurement by policymakers, promotion of environmentally conscious consumer behaviors, and the development of new sustainable technologies and methodologies by researchers.

Specifically, SDG 8's fulfillment is monitored using indicators like Real GDP per capita, investment share of GDP, employment rates, and the gap between EU and non-EU citizens in unemployment and training. For our study, Real GDP per capita is used to represent economic growth in the V4 countries.

SDG 12's achievement is measured through indicators such as the consumption of chemicals, resource productivity, CO₂ emissions per km from new passenger cars, circular material use rate, generation of non-mineral waste, and value added in the environmental goods and services sector.

Gross Domestic Product (GDP) is employed as a measure of economic activity and a surrogate for changes in a nation's living standards. It quantifies the total final output of goods and services produced by an economy within a specified period. Real GDP per capita is determined by dividing the inflation-adjusted GDP by the average population for a specific year and is used as the independent variable in our study.

The Circular Material Use Rate (CMR) quantifies the proportion of materials recycled back into the economy relative to the total materials used, capturing the essence of sustainable production and consumption. The broader metric of Domestic Material Consumption (DMC) aggregates all materials used domestically, while the CMR considers materials recycled within and across borders minus imports destined for recovery. A higher CMR value indicates a greater substitution of secondary materials for primary resources, thereby mitigating the environmental impact of raw material extraction.

The empirical segment of our research involves analyzing these indicators to assess progress towards SDG 8 and SDG 12 in the V4 countries. The data for this research predominantly come from Eurostat. Descriptive statistics and regression analysis are the primary methods used to investigate the effects of these variables, aiming to answer the research questions posed. The empirical analysis is based on secondary data obtained from Eurostat, which ensures consistency and comparability across countries. The study examines the relationship between economic growth and sustainable production and consumption in the Visegrad Group (V4) countries using real GDP per capita and the Circular Material Use Rate as key indicators corresponding to SDG 8 and SDG 12, respectively. Real GDP per capita, expressed in constant prices, serves as the independent variable and represents economic development, while the Circular Material Use Rate is used as the dependent variable to capture the degree of material circularity within national economies.

The statistical analysis was conducted using STATA 19 and Jamovi 2.7.14 statistical software. Descriptive statistical methods were first applied to explore basic characteristics, trends, and variability in the data for each country. Subsequently, country-specific simple linear regression models were estimated to assess the strength, direction, and statistical significance of the relationship between real GDP per capita and the Circular Material Use Rate. The use of separate

regression models for each country allows for a clearer identification of cross-country differences and avoids potential aggregation bias.

The regression results were evaluated using standard statistical measures, including the Pearson correlation coefficient (R), the coefficient of determination (R^2), adjusted R^2 , F-statistics, and corresponding p-values. Statistical significance was assessed at conventional significance levels (5% and 10%), taking into account the limited number of observations. The results are interpreted as correlations rather than causal effects, as the applied methodology does not control for additional explanatory variables.

The selection of the Circular Material Use Rate as a proxy for sustainable consumption and production is justified by its direct relevance to circular economy principles and its role as an official SDG 12 indicator monitored by Eurostat. This indicator reflects the extent to which secondary materials substitute primary raw materials, thereby reducing environmental pressures associated with resource extraction and waste generation. The use of real GDP per capita as an indicator of economic growth aligns with standard practice in empirical economic research and enables meaningful cross-country comparison.

Given the exploratory nature of the study and the relatively short time series available, a parsimonious bivariate regression framework was deliberately chosen. This modelling approach allows for transparent interpretation of results and minimizes the risk of overfitting. While more complex econometric models could capture additional structural and policy-related factors, the applied methodology provides a suitable first-step assessment of whether economic growth and circular material use are empirically associated in the V4 countries.

The choice of a bivariate linear regression framework reflects the exploratory nature of the study and its focus on identifying basic associations between economic growth and circular material use within the SDG framework. Given the limited number of observations and the objective of cross-country comparison, a parsimonious model was preferred to avoid overfitting and to maintain interpretability of results. While more complex econometric models could capture additional dynamics, the selected approach provides an appropriate first-step assessment of whether economic growth and sustainable resource use move together in the V4 countries. The results are therefore interpreted as indicative correlations rather than causal relationships [28] [29].

3 Results

This analysis focuses on evaluating selected Sustainable Development Goals as instruments to promote sustainable consumption, production, and economic growth within Slovakia and the other V4 countries.

3.1 Results of the Research

Table 1 confirms a strong positive correlation (0.85) between Real GDP per capita, as a measure of economic development, and the Circular Material Use Rate in the Czech Republic. The linear relationship between these two indicators is statistically significant, exceeding 99%. Real GDP per capita serves as an indicator of economic activity and a proxy for assessing material living standards in a country. However, it offers a restricted view of economic welfare [30].

Table 1
Results of the Regression Analysis in the Czech Republic

Model Summary (Czechia_material_use_rate)					
R	R Square	Adjusted R Square	Std. Error of the Estimate		
0.85	0.72	0.67	0.56		

ANOVA (Czechia_material_use_rate)					
	Sum of Squares	df	Mean Square	F	Sig.
Regression	4.77	1	4.77	15.35	0.008
Residual	1.87	6	0.31		
Total	6.64	7			

Coefficients (Czechia_material_use_rate)					
	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-7.95	3.73	0.00	-2.13	0.071
Czechia_GDP_per_capita	0.00	0.00	0.85	3.92	0.008

Source: own processing, data extracted from Eurostat [28, 29]

The regression analysis model is illustrated in Figure 2. Based on the regression model, we can predict the development of the dependent variable.

The moderate positive correlation (0.65) between the Real GDP per capita representing the economic growth and the indicator Circular material use rate in Hungary was confirmed (Table 2). The linear dependence between these two indicators exists at the level of significance 92%.

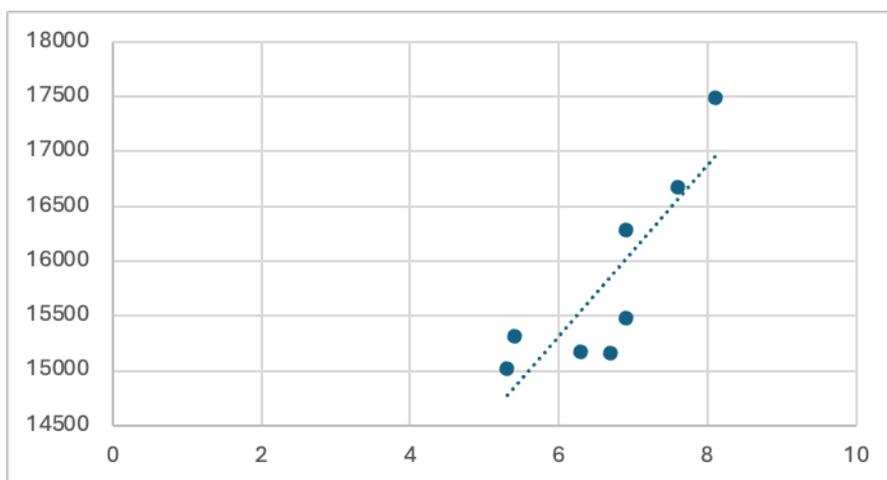


Figure 2
Regression Analysis Model – Czech Republic

Table 2
Results of the Regression Analysis in Hungary

Model Summary (HU_material_use_rate)

R	R Square	Adjusted R Square	Std. Error of the Estimate
0.65	0.43	0.33	0.42

ANOVA (HU_material_use_rate)

	Sum of Squares	df	Mean Square	F	Sig.
Regression	0.79	1	0.79	4.44	0.080
Residual	1.06	6	0.18		
Total	1.85	7			

Coefficients (HU_material_use_rate)

	Unstandardized Coefficients		Standardized Coefficients		t	Sig.
	B	Std. Error	Beta			
(Constant)	1.11	2.28	0.00		0.48	0.643
HU_GDP_per_capita	0.00	0.00	0.65		2.11	0.080

Source: own processing, data extracted from Eurostat [28] [29]

Table 3 contains the regression model summary. In Slovakia, the weak positive correlation (0.34) between the Real GDP per capita and the indicator Circular material use rate was confirmed. The linear dependence between these two indicators exists at the level of significance less than 60%.

Slovakia's existing economic model poses environmental hazards, promotes waste in production and consumption processes, and contributes to biodiversity loss, ecosystem degradation, and the depletion of natural resources. Adopting the 2030 Agenda presents an opportunity to steer the economy towards environmental sustainability.

Table 3
Results of the Regression Analysis in Slovakia

Model Summary (SK_material_use_rate)					
R	R Square	Adjusted R Square	Std. Error of the Estimate		
0.34	0.43	-0.03	0.33		
ANOVA (SK_material_use_rate)					
	Sum of Squares	df	Mean Square	F	Sig.
Regression	0.09	1	0.09	0.81	0.404
Residual	0.67	6	0.11		
Total	0.76	7			
Coefficients (SK_material_use_rate)					
	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	2.96	2.06	0.00	1.44	0.193
SK_GDP_per_capita	0.00	0.00	0.34	0.90	0.404

Source: own processing, data extracted from Eurostat [28, 29]

In Poland, there is no dependence between the Real GDP per capita and the indicator Circular material use rate. R is equal to 0.16 and the level of significance is lower than 30%. F value is greater than 0.05, so it is recommended to choose another independent variable.

Table 4
Results of the Regression Analysis in Poland

Model Summary (PL_material_use_rate)					
R	R Square	Adjusted R Square	Std. Error of the Estimate		
0.16	-0.14	0.33	1.22		
ANOVA (PL_material_use_rate)					
	Sum of Squares	df	Mean Square	F	Sig.
Regression	0.24	1	0.24	0.16	0.704
Residual	8.94	6	1.49		
Total	9,17	7			

Coefficients (PL_material_use_rate)					
	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	13.19	6.07	0.00	2.17	0.066
PL_GDP_per_capit a	0.00	0.00	-0.16	-0.40	0.704

Source: own processing, data extracted from Eurostat [28] [29]

Figure 3 illustrates the circular material use rate in Slovakia, which raises over 9% [31]. From 2010 to 2017, this rate generally hovered around 5%. In comparison, the average rate for the EU-27 was 11.2%. From 2010 to 2022, the circular material use rate in the EU – representing the proportion of material usage derived from recycled waste – rose from 10.7% to 11.5%. However, this rate has plateaued since 2012. Meanwhile, the Czech Republic has experienced sustained growth in its circular material use rate.

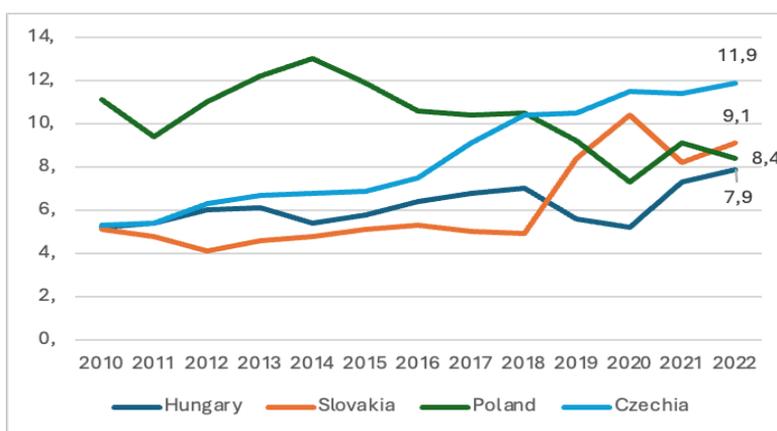


Figure 3

Circular material use rate in percentage (2010-2022)

The empirical results reveal considerable heterogeneity among the Visegrad Group countries. A strong positive relationship between real GDP per capita and the Circular Material Use Rate was identified in the Czech Republic, while a moderate relationship was observed in Hungary. In Slovakia, the relationship appears weak, and no statistically significant association was found in Poland. These findings indicate that economic growth may be associated with more efficient and circular resource use, but only under specific national conditions rather than as a general rule.

The observed regional disparities suggest that structural and institutional factors play a decisive role in shaping the relationship between economic performance and

circular material use. In the Czech Republic, sustained investments in industrial modernization, waste management infrastructure, and circular economy-related policies may have facilitated a stronger alignment between economic growth and sustainable resource use. In contrast, the weaker or absent relationships observed in Slovakia and Poland may reflect differences in industrial structure, slower diffusion of circular practices, or limited effectiveness of policy instruments supporting material circularity. These results underline that economic growth alone is not sufficient to drive sustainable production and consumption outcomes without complementary institutional frameworks and targeted policy measures.

3.2 Strategic Implications of SDGs

The provision of sustainable energy must be strategically planned to satisfy the immediate needs of the current generation without jeopardizing the ability of future generations to meet their own needs, as noted by Iacobuta and Ifrim [30]. This involves a significant emphasis on renewable energy sources and technologies that enhance energy efficiency.

By 2007, all four V4 countries had established national sustainable development strategies and had developed sets of indicators to measure progress. While the strategies share many features, including the adoption of long-term framework strategies by three of the countries, Slovakia has opted for a mixed strategy approach. However, Slovakia's commitment alone is not enough for sustainable development success; it requires the active involvement of all societal sectors. This includes NGOs, the private sector, academia, interest groups, local governments, and the public at large. A robust institutional framework supporting the 2030 Agenda reflects these inclusive and collaborative efforts, embodying the partnership principle central to the agenda's implementation.

Corporate and industrial interests have significantly influenced the development of sustainable development concepts and strategies from the beginning, as discussed by Streimikiene et al. [33]. This influence has led to the enactment of stringent regulatory laws in several developed countries [34]. Specifically, Goal 12 of the SDGs aims to ensure sustainable consumption and production patterns and includes eight specific targets along with three implementation-related targets. The European Union primarily approaches sustainability through the prism of production efficiency, focusing on the sustainable management of natural resources, reduction of food production losses, chemical and waste management, sustainable corporate practices and reporting, and sustainable public procurement practices.

Notably, while Goal 12 includes targets aimed at reducing food waste at the consumer level and promoting consumer actions for sustainable lifestyles through access to information, it does not sufficiently address the broader unsustainable consumption patterns directly. The targets geared towards reducing waste generation and rationalizing fossil fuel subsidies are designed to address both

production and consumption [16]. However, in practice, they tend to spotlight new business opportunities more than they encourage significant changes in consumer behaviors and lifestyles. This gap highlights the need for a more holistic approach to embedding sustainability deeply into both corporate and consumer practices to truly transform production and consumption patterns across societies.

The findings of this study carry several policy-relevant implications. In countries where a stronger relationship between economic growth and circular material use was identified, particularly the Czech Republic, the results suggest that consistent policy support for circular economy principles can reinforce the compatibility of economic and environmental objectives [35] [36]. Policymakers should therefore continue to promote investments in recycling infrastructure, secondary raw material markets, and innovation in resource-efficient technologies.

For countries with weaker or insignificant relationships, such as Slovakia and Poland, the results indicate the need for more targeted and differentiated policy interventions [37] [38]. These may include strengthening regulatory frameworks for waste prevention and recycling, providing financial incentives for firms to adopt circular business models, and improving coordination between national and regional authorities responsible for sustainability policies. In addition, greater emphasis on education, skills development, and public awareness could help stimulate demand for circular products and services, thereby supporting the transition toward sustainable consumption patterns [39].

Overall, the results suggest that policy strategies aimed at achieving SDG 8 and SDG 12 should be context-specific, taking into account national economic structures, institutional capacities, and levels of circular economy maturity, rather than relying on uniform policy solutions across countries.

Conclusions

This paper examined the relationship between economic growth, measured by real GDP per capita, and sustainable consumption and production, represented by the circular material use rate, in the Visegrad Group (V4) countries within the framework of SDG 8 and SDG 12. The empirical results indicate a strong positive relationship between these indicators in the Czech Republic and a moderate positive relationship in Hungary. In contrast, no statistically significant relationship was identified in Slovakia and Poland during the observed period.

These findings suggest that, within the specific context of selected indicators, countries, and time horizons, higher levels of economic development may coincide with improved performance in circular material use. However, this relationship is neither uniform across all V4 countries nor sufficiently robust to support broad generalizations about the compatibility of economic prosperity and environmental sustainability beyond the studied cases. Rather than confirming a universal pattern, the results highlight substantial cross-country heterogeneity in how economic growth relates to circular economy outcomes.

Overall, this study contributes to the literature by offering context-specific empirical evidence on the relationship between economic growth and circular material use, in the V4 countries.

The findings underscore the importance of cautious interpretation and reinforce the need for tailored policy approaches that reflect national conditions rather than assuming universally applicable outcomes in the pursuit of sustainable development.

Limitations of the Study

The findings of this study should be interpreted in light of several methodological and conceptual limitations arising from the scope and design of the research. The analysis focuses exclusively on SDG 8 (Decent Work and Economic Growth) and SDG 12 (Responsible Consumption and Production). While these goals are directly relevant to the research objective, sustainable development is inherently multidimensional. The exclusion of other closely related goals, such as SDG 9 (Industry, Innovation and Infrastructure), SDG 11 (Sustainable Cities and Communities), or SDG 13 (Climate Action), limits the ability to capture broader sustainability dynamics and interlinkages among the SDGs.

The empirical investigation is confined to the four Visegrad Group (V4) countries, which allows for a focused regional comparison but limits the external validity of the results. Consequently, the findings cannot be generalized to the European Union as a whole or to countries with different economic structures, institutional settings, or levels of development. In addition, the study relies on available Eurostat data over a relatively limited time period, resulting in a small number of observations for each country. This constrains statistical power and reduces the robustness of the regression results, particularly in cases where the relationships between variables appear weak or statistically insignificant.

From a methodological perspective, the research applies bivariate linear regression analysis, which captures correlations but does not allow for causal inference. The model does not account for potentially influential factors such as the stringency of environmental regulations, technological innovation, industrial structure, or specific policy measures related to the circular economy. As a result, the observed relationships may be affected by omitted variable bias. Finally, the positive relationships identified in the Czech Republic and Hungary should be interpreted as context-specific outcomes rather than evidence of a general rule. Structural differences among the V4 countries, including variations in industrial legacy, policy implementation, and institutional capacity, are likely to play an important role in shaping the relationship between economic growth and circular material use.

Future Research Directions

First, future studies could broaden the scope of analysis by incorporating additional SDGs and indicators. Including goals related to innovation, climate action, energy, and social inclusion (e.g. SDG 9, SDG 11, SDG 13) would allow for a more comprehensive assessment of sustainability trade-offs and synergies. The use of composite or multidimensional indicators could also better capture the complexity of sustainable development outcomes.

Second, expanding the geographical coverage beyond the Visegrad Group countries would enhance the generalizability of results. Comparative analyses involving other EU member states or regional groupings could help identify whether the observed relationships are specific to Central and Eastern Europe or reflect broader European patterns. Such extensions would also enable the exploration of convergence and divergence trends in circular economy performance across countries.

Third, future research should consider methodological extensions, particularly the application of panel data models, dynamic regression techniques, or causal inference methods. These approaches would make it possible to control for unobserved heterogeneity, incorporate additional explanatory variables, and better assess the direction and strength of causal relationships between economic growth and circular economy indicators.

Finally, incorporating policy, institutional, and structural variables – such as environmental regulation intensity, innovation capacity, industrial structure, or public investment in circular economy initiatives – could provide valuable insights into the mechanisms that condition the relationship between growth and sustainability. This would support more nuanced policy recommendations tailored to national contexts.

Generally, extending research along these dimensions would contribute to a more robust and policy-relevant understanding of how economic development can be aligned with sustainable consumption and production, while avoiding overgeneralization and respecting contextual differences across countries.

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