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THE ECONOMIC AND ENVIRONMENTAL DIMENSION OF SUSTAINABLE DEVELOPMENT AND EVALUATION OF SELECTED AREAS IN EU COUNTRIES

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ABSTRACT. The paper discusses current issues of economic policy in the context of the initial conditions of sustainable development. The aim of the article is to map the view of sustainable development, to evaluate its selected areas in the economic and environmental dimension and their impact on economic development in EU countries. Using a panel data analysis in the years 2010-2022, the influence of selected areas (indicators) of sustainable development in the context of economic development is examined in EU countries. The results showed the greatest positive impact of economic sustainability indicators in the field of circular economy - Resource productivity and Material footprint in the context of economic development. On the other hand, the greatest negative impact on the economic development of EU countries is associated with share of environmental taxes in total tax revenues and circular material use rate. At the same time, the results confirmed certain differences in the impact of the examined areas of economic and environmental sustainability between EU countries with a higher and lower economic level than the EU average. The findings this research demonstrate the importance of specific areas of economic and environmental sustainability in the examined groups of EU countries.

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Introduction

The concept of sustainable development, in turn, represents the development of production and consumption that enables the satisfaction of today's needs in a way that does not limit the satisfaction of the needs of future generations (Apostu *et al.,* 2023). It is an economic development that respects the planetary limits to growth, and the relationship of development to natural resources is key. According to (Biswas *et al*., 2021, Van Oostrum, 2021) practical measures in the direction of realizing sustainable development depend on the will of individual countries (governments) and include issues such as natural resource depletion, environmental pollution, resource scarcity, uneven economic development.

According to Pavlik (2014); Biely *et al.* (2018); Simamindra & Rajaonarivo (2024); Usubiaga-Liano *et al*. (2024), we distinguish between strong and weak sustainability. Weak sustainability implies that the overall economic value of the resources and the products derived from them will not be reduced in the future, i.e., it admits that primary, non-renewable resources can be extracted, provided that an appropriate counter-value is created (i.e., extraction is not at a loss) (Biely *et al.,* 2018). Strong sustainability is currently considered difficult to implement in the short and medium term, requiring a non-decreasing value of resources, i.e. the principle of strong sustainability only allows for the drawing of renewable resources, and does not consider non-renewable resources as an energy source at all (Usubiaga-Liano *et al*., 2024). The most frequently encountered sustainability within economic and social development is economic or fiscal and financial, environmental, social but also global sustainability (Addai *et al*., 2023; Gao & Fan, 2023; Ali & Raissi, 2024); Pehlivanoglu *et al.,* 2024; Kudelko, 2025).

The issue of sustainable development is examined from various perspectives and approaches. Previous research has focused primarily on key issues of sustainable development, with an emphasis on its pillars and sustainable development goals (Biswas *et al.,* 2021; Anselmi *et al.,* 2024; Firoiu *et al.,* 2025; Kudelko, 2025). In connection with sustainable development, selected areas are examined such as the circular economy (Hysa *et al.,* 2020; Chen & Pao, 2022; Georgescu et al., 2025;), green deal and trade (e.g. Hereu-Morales *et al.,* 2024; Stockmann, 2024) assessment of new climate and energy targets (Streimikiene, 2025) or specific policies, in particular agricultural policy, bioeconomy, and research, development, and innovation (Brodny & Tulak, 2023; Arru *et al.,* 2024; Ares-Sainz *et al.,* 2025; Aziz *et al.,* 2024).

Research in the field of sustainable development has examined, in particular, approaches, dimensions, specific areas, and objectives of sustainable development not only from the perspective of the EU27 or EU28 countries (Ali & Raissi, 2024; Caglar *et al.,* 2024; Bodislav *et al.,* 2025; Kakar *et al.,* 2025), but also according to selected groups of countries, such as Central and Eastern Europe or the V4 countries (Addai *et al.,* 2023; Kowalska *et al.,* 2024; Stefanachi & Grecu, 2025). Other authors have assessed the status of sustainable development in relation to the achievement of individual goals in specific EU countries (Stankowska, 2022; Mikalauskas & Stanislovaityte, 2025; Streimikiene, 2025) or focused regional approaches to sustainability (Pop & Stamos, 2025; Biggeri *et al.,* 2025).

The aim of the article is to map the view of sustainable development, to evaluate its selected areas in the economic and environmental dimension and their impact on economic development in EU countries. In relation to the objective, the subject of the research is economic and sustainable development in a narrower context. In our case, we investigate sustainable development, particularly its significance in economic and environmental terms, and evaluate selected areas of sustainable development in EU countries. Compared to other studies, we examine the economic and environmental dimensions of sustainable development not only in EU countries, but also from the perspective of two groups of EU countries with higher and lower economic levels than the EU average. For a more detailed examination we use specific indicators representing areas of sustainable development and the economic level of countries. Based on an analytical approach, we assess the impact of selected indicators of sustainable development (in the economic and environmental dimensions) on the economic level (measured by GDP per capita) in all EU countries and groups EU countries (with a higher and lower economic level) between 2010 and 2022 is examined using panel data analysis. This view allowed us to evaluate in greater detail the impact of economic and environmental sustainability indicators in the context of economic development in the EU countries examined.

In relation to the stated objective, three research questions are verified in the EU countries. RQ1: Do the indicators of the circular economy have a significant positive impact on the economic level of EU countries? RQ2: Do environmental sustainability indicators predominantly have a negative impact on the economic level of EU countries? RQ3: Is there a difference in the impact of economic and environmental sustainability determinants on economic growth between EU countries with higher and lower economic levels?

1. Literature review

Sustainable development is a very complex topic that has received attention from different perspectives (Moran-Blanco, 2022; Kharazishvili *et al.*, 2025; Kudelko, 2025; Mishchuk *et al.*, 2023; Ylipulli *et al.*, 2025). It reconciles economic and social progress with full preservation of the environment and seeks to eliminate or mitigate the negative effects of the current way of development of human society. As stated in a number of researches (e.g. Biswas *et al.*, 2021; Apostu *et al.*, 2023; Anselmi *et al.*, 2024; Firoiu *et al.*, 2025) the central issue of sustainable development is to preserve the quality of life and to provide for the needs of present generations without compromising the fulfillment of the needs of future generations and other people. Historically, sustainable development was based on the need to better protect nature and the environment, but today it also extends to the area of good and effective governance and management of public matters (Pop & Stamos, 2025; Stockmann, 2024; Ares-Sainz *et al.*, 2025). To achieve true sustainable development, coherent public policies in all their forms such as strategies, laws and financial instruments need to be created (Mata & Domingues, 2025).

The 2030 Agenda, a global agreement adopted by the United Nations (UN) in 2015, forms the basis for global cooperation on sustainable development. It includes 17 Sustainable Development Goals (SDGs) to be achieved by 2030 (United Nations, 2015; Biswas *et al.*, 2021; Firoiu, *et al.*, 2025). As confirmed by numerous studies (Addai *et al.*, 2023; Stockmann, 2024; Streimikiene, 2025) the European Union has long positioned itself as a global frontrunner for sustainability and climate protection. As states Hereu-Morales *et al.* (2024) transitioning towards a sustainable society (through the European Green Deal) is at the core of public planning in the EU and the agenda for sustainable development actualizes sustainability analysis of countries' social, ecological, and economic conditions.

According to Addai *et al*. (2023) the EU and OECD should implement member-targeted policies on economic growth and fossil fuel use towards regulating industrial pollution, water use, and population control; (2) the EU and OECD member countries should invest in environmental technologies through green research and development (R&D) to transform and ensure productive energy use. Ares-Sainz *et al.* (2025) were proposed a total of 142 sustainability indicators across environmental (7 areas), social (5), and economic/circularity (4) pillars. Environmental sustainability and current issues of the European Green Deal are also addressed by other authors (e.g. Hereu-Morales *et al.,* 2024). Stockmann *et al.* (2024) notably, it critically evaluates the Green Deal's capacity to open and sustain spaces for translating sustainability across horizontally and vertically fragmented realms of EU governance. Hereu-Morales *et al.* (2024) concludes that economic growth is the predominant focus in public planning and that the EGD needs a review of various environmental aspects to be considered the master plan for a transition towards a sustainable EU.

Other authors (e.g. Ali *et al.,* 2024; Pehlivanoglu *et al.,* 2024, Firoiu *et al.,* 2025; Štreimikienė, 2024) have evaluated environmental sustainability and renewable resources in the context of current sustainability issues. Firoiu *et al.* (2025) investigates sustainable production and consumption dynamics in European Union countries and provides critical insights into the evolution of responsible consumption and production across EU countries and trends until 2030. Ali *et al.* (2024) confirm the existence of a positive and significant long-term nexus between environmental sustainability, renewable energy consumption, and economic growth in EU-28 countries. Pehlivanoglu *et al.* (2024) found that energy efficiency, energy intensity, energy dependency, and renewable energy utilization exhibits a different degree of economic impact the sections of examined EU countries. Addai *et al.* (2023) contends that economic growth exerts short-term environmental degradation but has long-term environmental benefits in Eastern Europe. Their results indicate that environmental sustainability is unidirectionally affected by economic growth.

In the context of sustainable development, the concept of circular economy, which is an integral part of sustainable development**,** should be mentioned (Apostu *et al.,* 2023). Circular economy can be seen as a waste management or a way to recycle materials and has become a key concept in a number of European Union policies (Friant *et al*., 2021; Gerasimova, 2024; Georgescu *et al.,* 2025; Potkány *et al.,* 2024). It deals with ways to improve the quality of the environment and human life by increasing the efficiency of production (Simamindra & Rajaonarivo, 2024; Kakar *et al.,* 2025; Toušek *et al.,* 2025). As stated by e.g. Hysa *et al.,* 2020; Arion *et al*., 2023) the circular economy aims to maintain the value of products, materials and resources for as long as possible in the economic cycle and to return them to the production cycle at the end of their life cycle, while minimising waste generation. Other research (e.g. Apostu *et al.,* 2023; Gerasimova, 2024; Gedvilaite & Ginevicius, 2024) also confirms that more stringent resource efficiency and circular economy measures are necessary to reduce material consumption and offset environmental impacts.

The strategic framework for a circular economy in the Czech Republic sets out 10 priority areas i.e. Products and Design; Industry, Raw Materials, Construction, Energy; Bioeconomy and Food; Consumption and Consumers; Waste Management; Water; Research, Development and Innovation; Education and Knowledge; Economic Instruments; Circular Cities and Infrastructure (MACZ, 2024). Current issues in the circular economy in the Czech Republic have been addressed, for example, in research (Setek *et al.,* 2025). In connection with the circular economy, other aspects of its impact on the environment, selected indicators, the role of specific public policies, and other areas of the circular economy are also being studied in the Czech Republic (Sonsky *et al.,* 2024; Alola *et al.,* 2025).

2. Methodological approach

Data from Eurostat on sustainable development and circular economy in EU countries were used to process the empirical analysis. The data were analysed for the period 2010-2022, which was the available period for most of the monitored indicators (see Eurostat, 2025a, 2025b).

The research sample represents the 27 EU countries. For the purposes of a more detailed examination, the EU countries have been divided into two groups and evaluated (with respect to their economic levels according to GDP per capita (in PPS EU27 2022). First group represent EU countries with a lower economic level than the EU average: Bulgaria, Czech Republic, Estonia, Greece, Spain, Croatia, Italy, Cyprus, Latvia, Lithuania, Malta, Hungary, Poland, Portugal, Romania, Slovenia, Slovakia. Second group represents EU countries with a higher economic level than the EU average: Austria, Belgium, Denmark, Germany, Ireland, France, Luxembourg, Netherlands, Finland, Sweden (Eurostat, 2025b).

Economic development or the economic level of countries is represented by the GDP per capita indicator. For the basic analysis, 13 indicators (variables) were used for sustainable development with a focus on the economic and environmental dimension and on the circular economy.

To use the data analysis panel, due to high correlation dependencies, 2 indicators had to be (Generation of plastic packaging waste per capita (GPPW) and Greenhouse gases emissions from production activities (GGEPA**)** were discarded and the impact of only 11 indicators on economic development was evaluated). At the same time, due to the unavailability of some data in the monitored time series 2010-2022, data related to selected areas of Sustainable development in selected years and EU countries had to be calculated for the use of the selected method. The indicators used for the panel data analysis are shown in *Table 1*.

Table 1. Use indicators for the panel data analysis

	Indicators/ variables	Abbreviation	Unit	Source
Dependent variables	GDP per capita	GDP	Euro per capita	Eurostat
Independent variables of circular economy	Circular material use rate	CMUR	Percentage	Eurostat
	Material footprint	MAFO	Tonnes per capita	Eurostat
	Resource productivity	REPR	Euro per kilogram	Eurostat
	Trade in recyclable raw materials	TRRM	Tonne	Eurostat
	Generation of municipal waste per capita	GMWA	Kilograms per capita	Eurostat
	Generation of packaging waste per capita	GPWA	Kilograms per capita	Eurostat
Independent variables of sustainable development	Air emission intensity from industry	AEII	Grams per euro	Eurostat
	Air emissions accounts totals bridging to emission inventory totals	AETB	Kilograms per capita	Eurostat
	Environmental tax revenues	ETRE	Million euro	Eurostat
	Share of environmental taxes in total tax revenues	SETTRE	Percentage of total revenues from taxes and social contributions	Eurostat
	Share of renewable energy in gross final energy consumption by sector	SREFEC	Percentage	Eurostat

Source: *Eurostat (2025a, 2025b)*

Furthermore, the effects of selected sustainable development indicators on the economic level (measured by GDP per capita) in EU countries and for groups of EU countries with a higher and lower economic level than the EU average in 2010-2022 is evaluated using a panel data analysis with fixed effects (*Table 4-6).*

Panel Data Analysis is a statistical research method used in social science and econometrics that combines time series and cross-sectional data to study changes over time. Time series and cross- sectional data can be thought of as special cases of panel data. The data are usually collected over time and over the same individuals and then a regression is run over these two dimensions (Pesaran, 2015). Panel data analysis has also been used in other research to assess sustainable development, similarly to our study (e.g. Busu & Trica, 2019; Hysa *et al*., 2020; Bodislav *et al*., 2025).

Fixed-effects models are a statistical technique (a form of regression analysis) for analyzing nonexperimental data. In the presence of unmeasured, unchanging variables that are correlated with the independent variable of interest and that also exert their own effect on the dependent variable, fixed-effects models come closer than does ordinary regression analysis to achieving unbiased estimates of causal effect (Farkas, 2005, p. 45). In panel data where longitudinal observations exist for the same subject, fixed effects represent the subject-specific means. In panel data analysis the term fixed effects estimator (also known as the within estimator) is used to refer to an estimator for the coefficients in the regression model including those fixed effects (one time-invariant intercept for each subject), (Gardiner *et al.,* 2009; Wooldridge, 2013).

The goal of this analysis is to estimate the effect of several independent variables on a dependent variable using a panel regression model. The data has a panel structure (multiple units observed over time). We use three regression models and examine the effects of selected sustainable development indicators on GDP per capita in the years 2010-2022 (for all EU countries (model - M1); for the group of EU countries with a higher economic level than the EU average (model - M2); for the group of EU countries with a lower economic level than the EU average (model - M3).

The panel data follows this structure:

- $i = 1,\ldots,27$: cross-sectional units (countries)
- $t = 2010,\ldots,2022$: time dimension (years)
- Total number of observations: 351

General fixed effects (FE) model:

$$y_{it} = \alpha_i + \sum_{k=1}^{K} \beta_k \, x_{kit} + \varepsilon_{it}$$

Where:

- y_{it}: the dependent variables (GDP)
- x_{kit}: regressors (CMUR, MAFO, REPR, TRRM, GMWA, GPPW, GPWA, GGEPA, AEII, AETB, ETRE, SETTRE, SREFEC)
- β_k: model parameters
- α_i: unit fixed effect – captures unobserved, time-invariant characteristics
- ε_{it}: idiosyncratic error

According to Baltagi (2021) it is used the F-test to test the consistence of the pooled OLS model (*Table 2*) and by the Hausman we examine whether individual effects in a panel data model are correlated with the explanatory variables, thereby helping to decide between using a fixed effects (FE) or a random effects (RE) model (*Table 3).*

Table 2. F-test results to assess the suitability of FE and OLS models for GDP

Group of countries	*p*-value *F*-test	Preferred Model
All	8.55e-85	FE
Higher economic level	2.47e-16	FE
Lower economic level	7.83e-42	FE

Source: *Authors*

Table 3. Results of the Hausman test to assess the suitability of FE and RE models for GDP

Group of countries	*p*-value Hausman test	Preferred Model
All	6.626e-10	FE
Higher economic level	0	FE
Lower economic level	0	FE

Source: *Authors*

3. Results

This part evaluates the impact of selected indicators of economic and environmental sustainability in the context of economic development in EU countries in the years 2010 - 2022.

3.1. The effect of selected indicators of sustainable development on GDP per capita in 27 EU Countries in 2010-2022

Using a panel data analysis and fixed effects model in the years 2010-2022, we examine indicators of sustainable development in the economic and environmental dimension and their effect on the economic level of EU countries (measured by GDP per capita). The results for the 27 EU countries (Model-M1) are shown in *Table 4.*

Table 4. The Effect of selected indicators of sustainable development on GDP per capita in years 2010-2022 (27 EU countries - Model M1)

term	estimate	std.error	statistic	p.value	p.value.signif
CMUR	-224.8	62.1	-3.62	0.000343	***
MAFO	463.5	73.98	6.265	1.231e-09	***
REPR	10682	811.6	13.16	8.654e-32	***
TRRM	0.0009278	0.0004957	1.872	0.06219	ns
GMWA	2.454	2.7	0.9091	0.364	ns
GPWA	27.9	12.8	2.18	0.02997	*
AEII	-1430	990.1	-1.445	0.1495	ns
AETB	0.4042	0.1784	2.265	0.02418	*
ETRE	-0.09526	0.0653	-1.459	0.1456	ns
SETTRE	-1009	170.4	-5.922	8.351e-09	***
SREFEC	139.7	62.43	2.239	0.02588	*

*Note: *** 0.0001 < p ≤ 0.001 highly significant, ** 0.001 < p ≤ 0.01 strongly significant, * 0.01 < p ≤ 0.05 significant*
Source: *Authors*

The results for the period 2010-2022 for the 27 EU countries (*Table 4* – Model M1) show that the seven variables examined - sustainable development indicators - have a statistically significant effect on GDP per capita. Specifically, five sustainable development indicators have a statistically significant positive effect on GDP per capita. These are material footprint (MAFO) and resource productivity (REPR) at 0.1% level, generation of packaging waste per capita (GPWA), share of renewable energy in gross final energy consumption by sector (SREFEC) and air emissions accounts totals bridging to emission inventory totals (AETB) at 5% level. This means that in EU countries an increase in resource productivity (REPR) of Euro per kilogram has an impact on an increase in GDP per capita of 10682 Euro and an increase in material footprint (MAFO) of 1tonne per capita has an impact on an increase in GDP per capita of 463.5 Euro. An increase of generation of packaging waste per capita (GPWA) and air emissions accounts totals bridging to emission inventory totals (AETB) by 1 kilogram per capita affects the increase of GDP (by 27.9 Euro per capita in case of GPWA and by 0.4042 Euro in case of AETB). At the same time, an increase in share of renewable energy in gross final energy consumption by sector (SREFEC) by 1% is reflected in an increase in GDP of 139.7 Euro per capita.

On the contrary, two indicators - share of environmental taxes in total tax revenues (SETTRE) and circular material use rate (CMUR) at 0.1% level affect GDP per capita statistically significant but negatively. This means that an increase in the share of environmental taxes in total tax revenues (SETTRE) by 1% of total revenues affects the decrease of GDP per capita of 1009 Euro per capita and a 1% increase in CMUR results in a decrease in GDP per capita of 224.8 Euro. The results also show that for four the indicators examined - trade in recyclable raw materials (TRRM), generation of municipal waste per capita (GMWA), air emission intensity from industry (AEII) and environmental tax revenues (ETRE) - there was no statistically significant effect on the economic development of 27 EU countries (*Table 4)*.

3.2. The effect of selected indicators of sustainable development on GDP per capita of two groups of EU countries in 2010-2022

In the period 2010-2022 we further examine the effect of indicators of sustainable development on GDP per capita in two groups of EU countries (with a higher and lower economic level than the EU average). The effects of examined indicators of sustainable development in economic and environmental dimension on GDP per capita for group of EU countries with a higher economic level than the EU average show *Table 5.*

In years 2010-2022 for the 10 EU countries with a higher economic level than the EU average (*Table 5*, Model-M2) results show that the seven sustainable development indicators have a statistically significant effect on GDP per capita. A statistically significant positive effect on GDP per capita have five indicators of sustainable development - resource productivity (REPR), air emissions accounts totals bridging to emission inventory totals (AETB), generation of packaging waste per capita (GPWA) and trade in recyclable raw materials (TRRM) at 0.1% level and material footprint (MAFO) at 1% level. This means that in EU countries with a higher economic level an increase in resource productivity (REPR) of Euro per kilogram has an impact on an increase in GDP of 14540 Euro per capita. An increase trade in recyclable raw materials (TRRM)) by 1 ton affects an increase in GDP of 0.002727 Euro per capita and an increase of air emissions accounts totals bridging to emission inventory totals (AETB) o 1kilogram per capita affects an increase of GDP by 1.991 Euro per capita. Simultaneously, an increase in the generation of packaging waste per capita (GPWA) o 1kilogram per capita results in an increase in GDP by 90.9 Euro per capita and an increase in material footprint (MAFO) by 1 ton per capita affects an increase in GDP by 372.6 Euro per capita.

Table 5. The Effect of selected indicators of sustainable development on GDP per capita in years 2010-2022 (EU countries with a higher economic level - Model M2)

term	estimate	std.error	statistic	p.value	p.value.signif
CMUR	-394.9	112.8	-3.502	0.00067	***
MAFO	372.6	133.2	2.798	0.006075	**
REPR	14540	1164	12.5	8.989e-23	***
TRRM	0.002727	0.0006195	4.403	2.507e-05	***
GMWA	-2.735	3.278	-0.8344	0.4059	ns
GPWA	90.9	24.43	3.72	0.0003162	***
AEII	-25631	17060	-1.502	0.1359	ns
AETB	1.991	0.2964	6.72	8.632e-10	***
ETRE	0.03588	0.07907	0.4538	0.6509	ns
SETTRE	-2252	480.6	-4.685	8.119e-06	***
SREFEC	108.3	103.5	1.046	0.2979	ns

*Note: *** 0.0001 < p ≤ 0.001 highly significant, ** 0.001 < p ≤ 0.01 strongly significant, * 0.01 < p ≤ 0.05 significant*

Source: *Authors*

In years 2010-2022 two indicators share of environmental taxes in total tax revenues (SETTRE) and circular material use rate (CMUR) at 0.1% level affect GDP per capita statistically significant but negatively. This means that an increase of share of environmental taxes in total tax revenues (SETTRE) o 1 % of total revenues affects a decrease in GDP per capita by 2252 Euro per capita and 1% increase in circular material use rate (CMUR) has an effect on the decrease in GDP per capita by 394.9 Euro per capita. In the case of the four indicators (GMWA, AEII, ETRE, SREFEC), no statistically significant effect on GDP per capita has been proven (*Table 5).*

In years 2010-2022 also we examine of effects of indicators of sustainable development on GDP per capita for group of 17 EU countries with a lower economic level (than the EU average). For a group of EU countries with a lower economic level, the results have shown a statistically significant effect on GDP per capita in the case of seven indicators of sustainable development (Model M3, *Table 6*).

Table 6. The Effect of selected indicators of sustainable development on GDP per capita in years 2010-2022 (EU countries with a lower economic level - Model M3)

term	estimate	std.error	statistic	p.value	p.value.signif
CMUR	157.2	39.17	4.014	8.529e-05	***
MAFO	134.5	39.6	3.397	0.0008287	***
REPR	-803.3	569.7	-1.41	0.1601	ns
TRRM	0.0004453	0.0003733	1.193	0.2344	ns
GMWA	6.087	1.804	3.375	0.0008926	***
GPWA	36.99	6.634	5.576	8.222e-08	***
AEII	-1233	414.9	-2.972	0.003336	**
AETB	0.1436	0.08868	1.62	0.1069	ns
ETRE	0.05157	0.05145	1.002	0.3174	ns
SETTRE	-343.1	79.89	-4.294	2.779e-05	***
SREFEC	195.6	35.93	5.444	1.57e-07	***

*Note: *** 0.0001 < p ≤ 0.001 highly significant, ** 0.001 < p ≤ 0.01 strongly significant, * 0.01 < p ≤ 0.05 significant*

Source: *Authors*

Table 6 shows that five indicators have a statistically significant positive effect on GDP per capita: circular material use rate (CMUR), material footprint (MAFO), share of renewable energy in gross final energy consumption by sector (SREFEC), generation of packaging waste per capita (GPWA) and generation of municipal waste per capita (GMWA) at the 0.1% level. This means that in EU countries with a lower economic level, a 1% increase in the circular material use rate (CMUR) has an impact on increase of GDP per capita of 157.2 euros per capita. An increase in the material footprint (MAFO) by 1 ton per capita affects an increase of GDP per capita by 134.5 euros per capita and a 1% increase in the share of renewable energy in gross final energy consumption by sector (SREFEC) has an impact on increase of GDP per capita of 195.6 euros per capita. At the same time, an increase in the generation of packaging waste per capita (GPWA) by 1kilogram per capita affects GDP growth by approximately 37 euros per capita and an increase in municipal waste generation per capita (GMWA) by 1 kilogram per capita affects an increase of GDP per capita by 6.09 euros per capita.

Two indicators – the share of environmental taxes in total tax revenue (SETTRE) at the 0.1% level and the intensity of air emissions from industry (AEII) at the 1% level – had a statistically significant but negative impact on GDP per capita. This means that a 1% increase in the share of environmental taxes in total tax revenue (SETTRE) affects a decrease of GDP per capita by €343 and an increase in industrial air emissions intensity (AEII) of 1 gram per euro affected a decrease in GDP per capita of 1233 euros per capita. At the same time, no statistically significant impact on GDP per capita was found for the four sustainable development indicators (REPR, TRRM, AETB, ETRE) (see *Table 6*).

In the group of EU countries with a higher economic level (Model-M2), economic development was accompanied by a stronger positive impact of resource productivity and material footprint. Conversely, the largest negative impact on GDP per capita was the share of environmental taxes in total tax revenues and the circularity rate of materials. In the group of EU countries with a lower economic level (Model-M3), the positive impact was mainly reflected in the share of renewable energy sources in gross final energy consumption by sector, material footprint and circular material use rate. Conversely, the air emissions intensity from industry and the share of environmental taxes in total tax revenues had a significant negative impact on the economic development of the group of EU countries with a lower economic level (*Table 5* and *Table 6).*

4. Discussion

In connection with our research also other studies (Addai *et al.*, 2023; Gao & Fan, 2023; Caglar *et al.*, 2024; Pehlivanoglu *et al.*, 2024), which examined sustainable development according to its dimensions and the influence of various determinants of sustainability on economic growth in the EU and individual EU countries, have come to similar conclusions. In our research, three research questions (RQs) were verified. Following the verification of research question (RQ1): "*Do the indicators of the circular economy have a significant positive impact on the economic level of EU countries?*", the results in 27 EU countries confirmed the positive impact of selected indicators of economic sustainability and circular economy (resource productivity, material footprint, share of renewable energy in gross final energy consumption by sector, generation of packaging waste per capita) on GDP per capita (see *Table 4).* The answer to the research question (RQ1) is affirmative (YES).

Similar to our research, other studies (Busu & Trica, 2019; Ferrante & Germani, 2020; Hysa *et al.*, 2020; Arion *et al.*, 2023; Georgescu *et al.*, 2025) confirm that circular economy indicators have a positive impact on economic growth and that private investment and the integration of recyclable materials significantly enhance the efficiency of the circular economy.

Radivojevic *et al.* (2024) confirm a strong positive correlation between circular economy indicators and GDP per capita. Their results revealed a positive and statistically significant impact of Resource Productivity, Generation of municipal waste per capita, and Recycling rate of municipal waste on economic growth. Simamindra & Rajaonarivo (2024) argue that there is no consensus on the definition of circular economy and that it varies according to sectors and actors. Authors also confirm the over-representation of circular economy practices based on weak sustainability in developed countries, while circular economy initiatives based on strong sustainability are most common in the Global South. Arion *et al.* (2023) also emphasize the importance of circular economy indicators on GDP per capita in the economic dimension and on greenhouse gas emissions in the environmental realm. This finding shows that circular economy indicators aggregated at the EU level not only have a beneficial impact on the economy but also on society and the environment.

Some previous studies examining sustainable development and circular economy have used indicators similar to those used in our research. Specifically, Busu & Trica (2019), in evaluating economic growth in the EU, similarly to our research, examined circular material use rate, recycling rate of municipal waste, trade in recycling materials, environmental taxes, and resource productivity as independent variables, and their findings also highlight that the circular economy generates sustainable economic growth across the EU. Other authors, Bodislav *et al.* (2025), also used similar indicators of sustainable development and circular economy. However, in comparison with our research, their findings indicate a direct and positive correlation between the consumption of recyclable materials and all independent variables (the raw material footprint, the trade in recyclable materials, investments in the circular economy sectors, the real GDP per capita, renewable energy sources, the circular material use rate), with the exception of greenhouse gas emissions within the 27 EU Member States.

The results of our research in relation to the verification of research question (RQ2): whether "*Do environmental sustainability indicators have a predominantly negative impact on the economic level of EU countries?*", confirmed the negative impact of indicators of economic and environmental sustainability (share of environmental taxes in total tax revenues, circular material use rate) on GDP per capita for a group of all 27 EU countries. In the case of GDP per capita, the negative impact of environmental sustainability (air emission intensity from industry) was only demonstrated for a group of 17 EU countries with a lower economic level than the EU average. Based on our findings, research question (RQ2) was only partially confirmed.

In support of our results, it can be stated that other studies have reached similar but also different conclusions regarding the impact of environmental development indicators on economic growth. Gao & Fan (2023) point out that environmental taxes have both positive and negative influences on CO2 emissions, whereas renewable energy consumption considerably reduces carbon emissions and that economic growth in European Union countries causes an increase in CO2 emissions but, however, financial progress greatly reduces CO2 emissions. From the findings of the research (Georgescu *et al.,* 2025, p.1), it can be concluded that "*high-emission countries face greater challenges in achieving environmental targets. However, progress varies across Member States due to regional disparities, inadequate recycling infrastructure, and inefficient municipal waste management*". In this context, other research (e.g. Scriosteanu & Criveanu, 2024) shows that sustainable development involves constant efforts to reduce pollution by using resources as efficiently as possible. Baran (2020) or Pisuttu *et al.* (2024) pointed out that, municipal solid waste and plastic waste management represent a significant global threat. However, the potential associated with plastic waste recycling remains largely untapped, causing irreversible damage to the environment. According to Pisuttu *et al.*

(2024, p. 1) "*there is no universal rule for waste recycling strategies and "the most effective ways of tackling environmental problems are to 'change the way we consume', as well as to 'change the way we produce and trade*". Other research, Chen & Pao (2022) than confirmed that, an increase in material recycling led to a decrease in waste generation, and economic growth led to circular economy growth.

In connection with the verification of the research question (RQ3), whether "*There is a different impact of economic and environmental sustainability determinants on economic growth between groups of EU countries with a higher and lower economic level than the EU average?*", we can conclude that both groups of EU countries, in the context of their economic development, influence different indicators of economic and environmental sustainability. The groups of EU countries also differ in the opposite effect of circular material use rate on GDP per capita. At the same time, in countries with a higher economic level, a significantly stronger influence of indicators (material footprint, share of environmental taxes in total tax revenues) is evident compared to the group of EU countries with a lower economic level (*Table 5 and Table 6).* The results of our research confirmed differences in the impact of specific indicators of economic and environmental sustainability on GDP per capita between groups of EU countries with a higher and lower economic level than the EU average. The answer to the research question (RQ3) is affirmative (YES).

Given that research focuses primarily on EU countries (27, 28) or selected groups of countries or the EU15 and the so-called "new" EU countries, there is not much research that has assessed the impact of sustainable development and economic growth according to the economic level of EU countries divided into two groups, as in our research. According to the United Nations (2015), from Goal 8 (Decent work & economic growth) of the 2030 Agenda for Sustainable Development, it can be concluded that economic growth has long been considered the only indicator of a country's development. However, economic growth alone may not be an indicator of a thriving economy, but rather one that postpones problems for later, which can be costly in the long run. Bieszk-Stolorz & Dmytrow (2023, p. 1) concluded that in the period of 2002-2021, "*Nordic countries had the highest degree of implementation Sustainable Development Goal 8, while Greece, Spain, Italy, Romania and Slovakia had the lowest.* Dembinska *et al.* (2022, p. 1) found in selected European countries the spatial differentiation of the GDP level and the ecological footprint. Their findings show that the ecological footprint in European countries decreased in the years 2009-2019 and was not evenly distributed. Kolodziejczak (2025, p.1) assessed that *a "high degree of servitization for sustainable development characterizes mainly the rich countries of the EU-15, while a lower one applies mainly to the countries of Central and Eastern Europe. However, high levels of servitization are not always reflected in good values of sustainable development".*

Conclusion

In our case, attention was paid to two pillars of sustainable development (economic and environmental) and within them we examined selected areas of sustainable development according to selected indicators for the period 2010-2022. The aim of the article was to map the view of sustainable development, to evaluate its selected areas in the economic and environmental dimension and their impact on economic development in EU countries.

The results in the 27 EU countries with the use of panel data analysis showed the greatest positive impact of economic sustainability indicators in the field of circular economy - resource productivity and material footprint in the context of economic development. A positive impact on economic development was also reflected in the share of renewable energy in gross final energy consumption by sector and generation of packaging waste per capita. On the contrary,

the results showed that the negative impact on the economic level of 27 EU countries is associated with the share of environmental taxes in total tax revenues and circular material use rate. In 2010-2022, the results showed that in the group of all 27 EU countries and in the group of EU countries with a higher economic level than the EU average, economic growth is influenced by similar areas (indicators) of economic and environmental sustainability. The results confirmed the different impact of the examined areas of economic and environmental sustainability on GDP per capita between EU countries with higher and lower economic levels. However, in both groups of EU countries, a different impact was observed only in the case of some determinants of economic and environmental sustainability. Differences can also be found in the opposite influence of circular material use rate on GDP per capita. At the same time, in countries with a higher economic level than the EU average, a stronger influence of indicators (material footprint, share of environmental taxes in total tax revenues) is evident compared to the group of EU countries with a lower economic level.

Due to the unavailability of some indicators, it was not possible to compare all originally intended areas of sustainable development in the European dimension. The research could not be carried out over a longer period of time (due to the availability of data for all key indicators of economic and environmental sustainability only until 2022). The effects of sustainable development indicators were analyzed (for a set of EU countries and groups of EU countries with higher and lower economic levels than the EU average) in the period 2010-2022. The findings achieved in the examined groups of EU countries demonstrate the importance of specific areas of sustainable development in the economic and environmental dimensions. This information can be useful for policymakers in the creation of economic and environmental policies. The results of the research also contribute to the examination of other areas within sustainable development in the European dimension. For future research, the authors foresee examining other areas of economic and environmentally sustainable development based on a more in-depth analysis of selected EU countries or geographical divisions of EU countries (e.g., Nordic countries, Western Europe, Central Europe).

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