DETERMINANTS OF ECONOMIC DEVELOPMENT IN ROMANIA: A MULTIDIMENSIONAL APPROACH

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Abstract

Over recent decades, humanity has increasingly begun to understand the importance of ensuring better subsistence for all current and future generations by pursuing economic prosperity within a pristine planet and a world governed by peace and partnerships between nations. Accordingly, through our research, we aim to assess the manner in which a series of economic, social, and environmental factors influence economic development in Romania between 2000 and 2024 (i.e., time-series data). To measure the notion of economic development, we used one of the most popular proxy variables, namely, real gross domestic product (GDP) per inhabitant. For the econometric analysis, we employ the Ordinary Least Squares (OLS) method with Newey-West standard errors. Our findings highlight that GDP per capita is positively influenced by the employed population, R&D spending, population's access to safely managed drinking water, and municipal waste recycling. Conversely, it is negatively influenced by people living in poverty, young people who are neither in education nor employed, inflation, and greenhouse gas emissions. Furthermore, we state that our econometric estimates are robust, not changing significantly when an alternative proxy dependent variable is introduced (i.e., the Human Development Index). Finally, we conclude that our results are consistent with those obtained by various scholars who have addressed the topic of economic development in Romania and internationally.

Keywords: *Economic development, Romania, OLS with Newey-West standard errors, Time-series models*

JEL Classification: *O11, O47, C32, C50*

1. Introduction

Over recent decades, humanity has increasingly begun to understand the importance of ensuring better subsistence for all current and future generations by pursuing economic prosperity within a pristine planet and a world governed by peace and partnerships between nations (UN, 1987). Accordingly, the subject of economic development has been highly researched worldwide (Iordan & Chilian, 2017; Iordan & Chilian, 2019; Iordan et al., 2023; Levine & Tantardini, 2023; Saman, 2023; Saman & Pauna, 2023).

While numerous academic documents explore the manner in which different macroeconomic factors foster or hinder economic development, a smaller number of works address this topic specifically for the case of Romania.

Considering the abovementioned, this research aims to contribute to the scientific literature by empirically gauging the effects of several economic, social, and environmental factors on economic development within Romania, spanning 2000-2024 (hence, we deal with time-series data). In this sense, through our paper, we intend to provide a straightforward answer to the following research question: *How do a range of economic, social, and environmental factors influence economic development in Romania over the past 25 years?* The notion of economic development is first proxied through real gross domestic product per inhabitant (the dependent variable) and second through the Human Development Index (HDI) to check the robustness of the results. The socio-economic and environmental factors (the independent variables) are individuals experiencing poverty, youth who are neither studying nor working, birth life expectancy, employed labor force, R&D expenditure, inflation, GHG emissions, access to water from an improved source, and municipal waste recycling. The econometric model applied to investigate the relationship between regressors and the predicted variable is Ordinary Least Squares with Newey-West standard errors, which provides the advantage of efficiently dealing with heteroskedasticity and autocorrelation in the residuals, so the inference is valid. Data visualization and statistics were performed using the Stata software package.

The remainder of this paper consists of the following main sections: Section 2 reviews the scientific literature on the topic of economic development worldwide, with a focus on Romania; Section 3 highlights the utilized data and methodology; Section 4 reveals the main results of the econometric analysis, along with discussions; Section 5 checks the robustness of the results obtained in the former section; the last section (Section 6) encompasses the conclusions, provides some limitations, and opens avenues for future research.

2. Literature review

When delving into the topic of economic development, it is essential to highlight the relation between two complex, well-known processes that contain the word 'economic' in their structure, namely: *(i)* economic growth, and *(ii)* economic development.

Economic growth depicts a proliferation of final goods and services production in a given period relative to the prior period, leading to an increase in a nation's aggregate real gross domestic product (i.e., a physical or material increase in quantity) (Goodland, 1995). Often, in empirical research, economic growth is measured by the increase in real output per capita. Therefore, it mainly refers to the quantitative size of a country (Barrier, 1987). Economic growth is of paramount importance because it is the foundation (though not sufficient) for a much broader process, namely, economic development.

In essence, economic development is part of the total development of society, which describes a long-term improvement in a country's economy, along with sound institutional arrangements that ensure secure livelihoods, better living standards, quality and inclusive health and education services, a decrease in poverty, etc. (Barrier, 1987). The tacit goal of economic development is to reduce the wealth disparity between the affluent and the less fortunate (Goodland, 1995), translating into an overall rise in economic and social well-being (Barrier, 1987). Accordingly, economic development involves not only a quantitative dimension of economic activities but also a qualitative one, this aspect being the primary distinguishing feature of economic development from economic growth (Barrier, 1987).

Over the years, economic development has remained a key research topic worldwide, receiving a great deal of attention among scholars and policymakers (Levine & Tantardini, 2023). As a result, there is a vast scientific literature examining how different factors influence economic development at both the country and global levels. In the following, we briefly scrutinize some relevant academic papers on the multifaceted topic of economic development.

It is well known from the Endogenous Growth Model that investments in research activities and education represent a salient engine of technological change, which further fuels long-term growth and development (Romer, 1990). In this light, in a recent study, Bano (2025) underscores the importance of spending on research and development (R&D) fields in achieving growth and development in the long run. This type of expenditure has a direct positive impact on facilitating technological progress, creating more efficient production methods, strengthening a state's capacity to adapt to global changes, and increasing overall resilience to shocks, all of which sustain economic prosperity. In the same vein, by applying statistical methods, Kučera and Fiľa (2022) empirically reveal that R&D expenditure spurs innovation, which is a driving force of competitiveness and wealth growth within an economy.

Moreover, the composition and characteristics of a population, such as health, education, professional training, and well-being, are other paramount factors that affect overall economic development (Dragoescu, 2015; Tomaziu-Todosia, 2019). Although the process by which individuals acquire skills and talents through education, study, or apprenticeship involves certain costs, it brings long-term benefits for the entire society (Smith, 2002). The reason is that the acquired expertise and proficiency make people more productive in the workplace, and hence building human capital represents a gain not only for the person in question but also for society as a whole (Smith, 2002). Given this, education and training are viewed as investments that shall yield substantial returns in the future.

In addition to the abovementioned, in line with the New Institutional Economics theory, North and Thomas (1973) provide clear evidence that economic institutions are indeed critical in shaping future economic development and human capital accumulation. Similarly, Acemoglu et al. (2014) support the idea of a close linkage between institutions, human capital, and development. The authors also emphasize that a successful economic system with effective governance structures is a core factor for a country's welfare and economic performance.

Overall, literature sheds light on the fact that economic development is a multidimensional process, shaped by a combination of factors acting at both macro and micro levels.

3. Data and methodology

In the present research, we aim to study the subject of economic development in Romania through an econometric analysis. Thus, our objective is to deliver an answer to the following research question: *How do a range of economic, social, and environmental factors influence economic development in Romania over the past 25 years?*

In any empirical analysis, a primary aspect is the use of proxy variables appropriate to the study undertaken, which have the ability to best capture the analyzed concepts. In the absence of such suitable variables, the results cannot be considered entirely consistent from an econometric perspective. In this sense, to measure the notion of economic development, we used one of the most common proxy variables, namely, real gross domestic product (GDP) per inhabitant. Regarding the socio-economic and environmental factors likely to influence economic development, we selected nine explanatory variables based on the existing literature (Dragoescu, 2015; Adrangi & Kerr, 2022; Zhu et al., 2022).

The data were extracted from the World Bank and Eurostat databases, at the level of Romania, for the period between 2000 and 2024 (i.e., time-series data). The reason for analyzing only 25 years was the total or partial lack of data for certain variables before 2000.

A detailed description of the set of variables used in our empirical study (i.e., notation, definition, and unit of measurement) can be found in table no. 1.

Table no. 1. Variables description: notation, definition, and unit of measurement

Notation	Definition and unit of measurement
GDP per capita (Y)	GDP per inhabitant is the total income earned through the production of goods and services divided by the total population. Unit of measurement: constant 2021 US$.
Poverty headcount (X_1)	The poverty headcount is the percentage of the population living in poverty according to the World Bank's Societal Poverty Line. Unit of measurement: % of total population.
Youth not in education/employment	It reflects the number of youth aged 15 to 24 who are neither enrolled in school, nor in formal training, nor employed, as a percentage of the total youth population. Unit of measurement:

(X_2)	% of youth population.
Life expectancy at birth (X_3)	It indicates the number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life. Unit of measurement: years.
Employment (X_4)	It indicates the proportion of the employed population aged over 15. Unit of measurement: % of the total population.
R&D expenditure (X_5)	Gross domestic expenditure on R&D covers capital and current expenditures in business enterprises, higher education, government, and private non-profit sectors. Unit of measurement: % of GDP.
Inflation (X_6)	Inflation, measured by the annual growth rate of the GDP implicit deflator, shows the rate of price change in the economy. The GDP implicit deflator is the ratio of GDP in current local currency to GDP in constant local currency. Unit of measurement: %.
GHG emissions (X_7)	Greenhouse gas (GHG) emissions per capita include the total annual emissions of the six GHG covered by the Kyoto Protocol from the energy, industry, waste, and agriculture sectors, standardized to carbon dioxide equivalent values divided by the total population. Unit of measurement: tons CO2e/capita.
Safely managed drinking water (X_8)	Safely managed drinking water reflects the percentage of people using drinking water from an improved source free from contamination. Unit of measurement: % of population.
Municipal waste recycling (X_9)	It indicates the share of recycled municipal waste in the total municipal waste generation. It includes material recycling, composting, and anaerobic digestion. Unit of measurement: %.

Source: World Bank and Eurostat.

In addition, figure no. 1 illustrates the evolution of each socio-economic and environmental indicator used in the regression analysis (period 2000-2024). Overall, the ten indicators show a positive trend, suggesting improvements in quality of life and economic conditions over the past 25 years. More explicitly, the variables GDP per capita, life expectancy at birth, employment, R&D expenditure, safely managed drinking water, and municipal waste recycling show an increasing trend, while the other variables (i.e., poverty headcount, youth not in education/employment, inflation, and GHG emissions) show a decreasing trend.

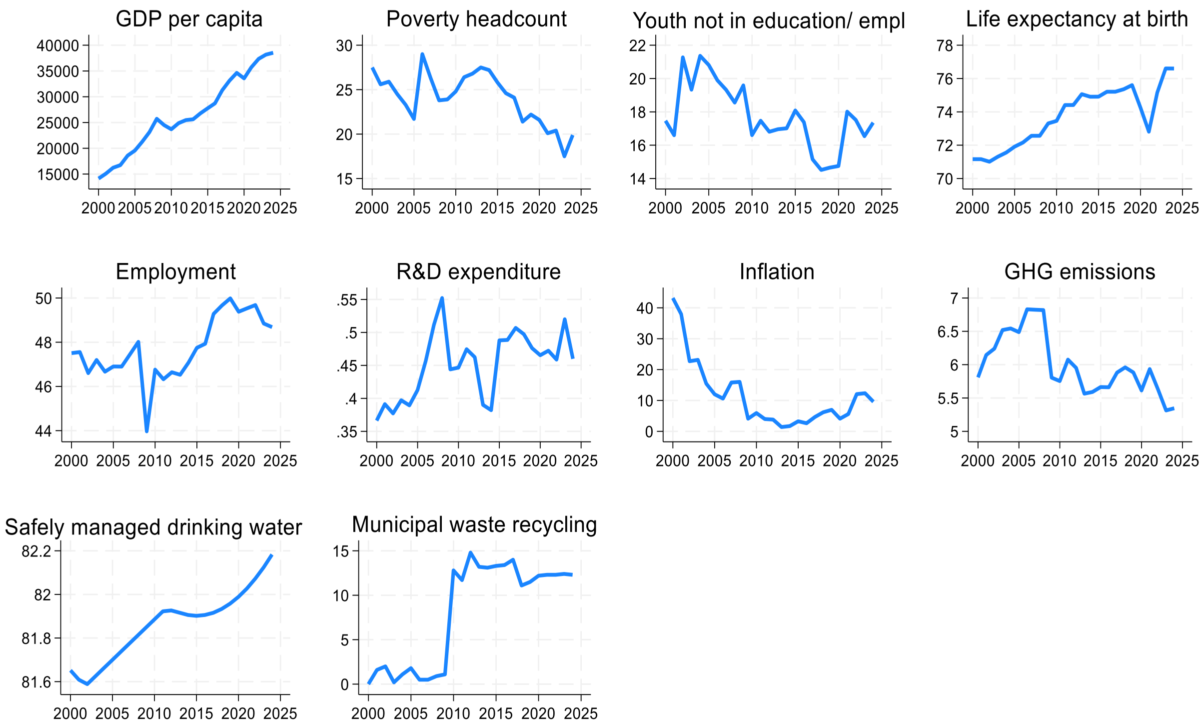

Figure no. 1. Evolution of socio-economic and environmental indicators, 2000-2024

Source: Authors' computation in Stata 19.

Furthermore, figure no. 2 illustrates GDP per inhabitant at current market prices, expressed in €/capita, for all Romanian counties in 2024. As observed, Bucureşti (54,800 €/capita), Cluj (27,000 €/capita), Timiş (23,800 €/capita), Braşov (21,400 €/capita), and Gorj (20,100 €/capita) are the top five best performing in terms of economic output, while at the opposite extreme, the counties with the lowest per capita GDP are Vaslui (8,300 €/capita), Giurgiu (8,700 €/capita), Botoşani (8,800 €/capita), Călăraşi (9,100 €/capita), and Suceava (9,900 €/capita). In 2024, at the country level, GDP per capita was on average €15,260/capita.

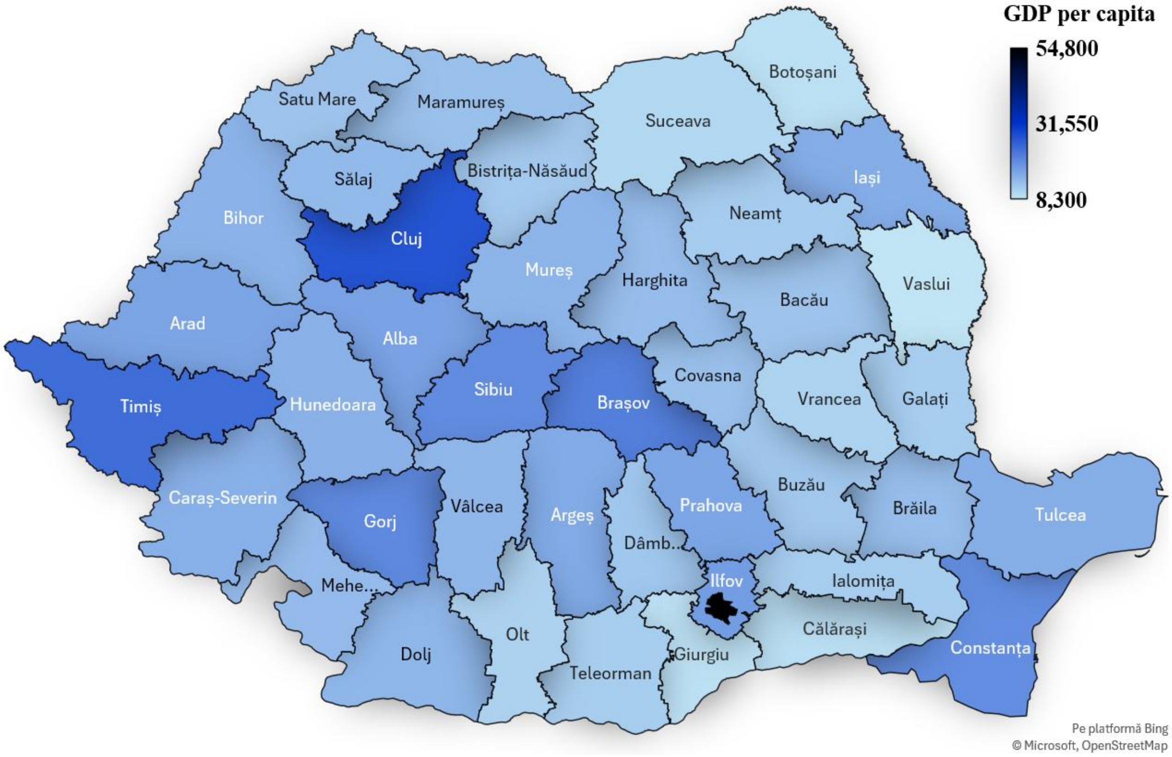

Figure no. 2. Per capita GDP by counties in Romania (€/capita), 2024

Source: Authors' computation in Excel based on data retrieved from Eurostat.

Importantly to mention, in recent years, Romania's economy has successfully overcome consecutive notable economic shocks (OECD, 2026). However, while total real GDP exhibited an upward trend, its growth rate has recently slowed. For example, in 2023, overall GDP growth was 2.3%, in 2024, it was only 0.9%, and it is projected to be 0.7% in 2025 (OECD, 2026).

A main step in the econometric study we will undertake is to ensure that the values of the ten variables are comparable. Thus, taking into account the fact that we have very different units of measurement (for example, our database includes variables measured in international dollars, percentages, years, and tons), we calculate Z scores (the classic standardization method), separately for the ten variables, in order to eliminate scale effects. For each variable, these scores are calculated by applying the following formula:

$$Z_t = \frac{x_t - \bar{x}}{s} \tag{1}$$

Where: t = year (from 2000 to 2024); Z_t = Z-score calculated for each year in the analysis; x_t = raw value of the variable in year t; $\bar{x}$ = sample mean of the variable values over the entire period; s = sample standard deviation of the variable values over the entire period. The common characteristic of standardized variables is a mean of 0 and a standard deviation of 1.

To have a clear overview of all variables, table no. 2 shows the descriptive statistics of the data, comprising: mean (central tendency measure), minimum and maximum values, standard deviation (dispersion measure, indicating on average, how spread out the values of a variable are from their mean), Kurtosis and Skewness parameters values (highlighting the data distribution), and number of observations.

Table no. 2. Descriptive statistics

Variable	Mean	Min	Max	Std. Dev.	Kurtosis	Skewness	No. Obs.
GDP per capita (Y)	0	-1.654	1.633	1	1.969	0.063	25
Poverty headcount (X_1)	0	-2.288	1.716	1	2.442	-0.418	25
Youth not in education/employment (X_2)	0	-1.646	1.871	1	2.401	0.215	25
Life expectancy at birth (X_3)	0	-1.521	1.634	1	1.730	-0.099	25
Employment (X_4)	0	-2.659	1.612	1	3.216	-0.293	25
R&D expenditure (X_5)	0	-1.681	1.984	1	2.071	-0.101	25
Inflation (X_6)	0	-0.934	2.965	1	5.260	1.673	25
GHG emissions (X_7)	0	-1.512	1.859	1	2.301	0.574	25
Safely managed drinking water (X_8)	0	-1.703	1.985	1	2.301	-0.067	25
Municipal waste recycling (X_9)	0	-1.351	1.147	1	1.228	-0.374	25

Source: Authors' computation in Stata 19.

Two key components of descriptive statistics are Kurtosis and Skewness parameters. The Kurtosis parameter highlights the extent to which the empirical distribution curve is higher or flatter compared to the normal distribution curve (for a normal distribution, it takes the value 3). The Skewness parameter shows the extent to which the empirical distribution is more right-skewed or more left-skewed than the normal distribution (for a normal distribution, it takes the value 0). Thus, based on the values presented in the table above, we draw the following conclusions: *(i)* evaluating the Kurtosis parameter, we can state that while the variables X_4 and X_6 have a leptokurtic distribution (i.e., the values' distribution curve is sharper than the normal one), the other variables have a platykurtic distribution (i.e., the values' distribution curve is flatter than the normal one); *(ii)* the Skewness parameter highlights the existence of a positive asymmetry ("longer tail" to the right) for the variables Y, X_2, X_6 and X_7, while the remaining variables present a negative asymmetry ("longer tail" to the left).

In addition, to provide a visual representation of the data distribution, in figure no. 3, we have plotted the distributions of all variables using histograms, over which the normal distribution curve is superimposed. Overall, we can state that although the data distributions deviate from the normal (Gaussian) distribution, for certain variables (e.g., Y, X_1, X_2), these deviations are not very significant.

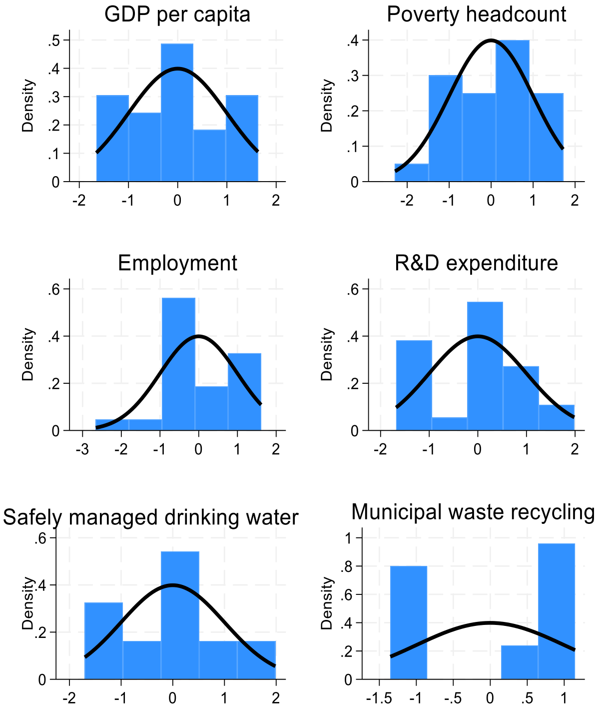

Figure no. 3. Histograms, with the normal distribution curve overlap
Source: Authors' computation in Stata 19.

Regarding the econometric analysis, to estimate the linear relationship between the previously specified explanatory variables and real GDP per capita, we employed the Ordinary Least Squares (OLS) method. This method is considered one of the most well-known and simple techniques used to estimate the parameters of linear models (Wooldridge, 2016). The principle underlying this method consists of minimizing the sum of squared residuals, denoted by ε^2, where ε^2 represents the difference between the observed values of the response variable and its estimated values (Wooldridge, 2016). The standard OLS method yields consistent estimates in cases of: *(i)* a linear relationship between the explained variable and the regressors, *(ii)* homoskedasticity, i.e. the error terms have constant variance for all values of the independent variables, *(iii)* serially uncorrelated errors, i.e. the errors in one year are not influenced by the errors in previous years, *(iv)* non-collinear independent variables, *(v)* exogenous independent variables, i.e. they are not correlated with the error term (Wooldridge, 2016). Given the aforementioned, in the current analysis, we apply the OLS method with Newey-West standard errors, which has the advantage of being robust to heteroskedasticity and serial correlation in error terms (StataCorp, 2025).

The linear multifactorial model equation has the following form:

$$Y_{i,t} = a_{it0} + a_{it1}X_{it1} + \cdots + a_{itn}X_{itn} + \varepsilon_{i,t} \quad (2)$$

Where: i = country (Romania); t = year (from 2000 to 2024); $Y_{i,t}$ = dependent variable; a_{it0} = intercept; $X_{it1}, \ldots, X_{itn}$ = independent variables; $a_{it1}, \ldots, a_{itn}$ = regression coefficients; $\varepsilon_{i,t}$ = error term. *Note*: given the small number of observations (namely, 25), we chose to apply a static model to avoid the risk of losing observations, as is the case with dynamic models.

4. Results and discussions

A salient step in econometric modeling is the study of the correlation between variables. Investigating this aspect is essential because, in situations where independent variables present very high correlations, econometric estimates can be distorted - in which case it is recommended to remove the variables in question from the model. Thus, in table no. 3, the correlation matrix can be found, which includes the correlation coefficients calculated for each pair of variables, as well as the statistical significance of each coefficient. The correlation coefficient takes values between -1 and 1, and it shows both the intensity of the link between two variables (weak, moderate, or strong) and the direction of the link (direct link: the variables evolve together, or inverse link: the variables evolve contrary). For example, in the case of two variables, a correlation coefficient of *(i)* 1 shows a strong and direct relationship, *(ii)* 0 reveals the absence of a linear relationship, and *(iii)* -1 indicates a strong and inverse relationship.

Table no. 3. Correlation matrix

Variables	Y	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9
Y	1									
X_1	-0.691 ***	1								
X_2	-0.576 ***	0.226	1							
X_3	0.857 ***	-0.408 **	-0.655 ***	1						
X_4	0.669 ***	-0.584 ***	-0.605 ***	0.436 **	1					
X_5	0.627 ***	-0.381 *	-0.350 *	0.510 ***	0.440 **	1				
X_6	-0.609 ***	0.153	0.259	-0.675 ***	-0.054	-0.440 **	1			
X_7	-0.588 ***	0.350 *	0.593 ***	-0.722 ***	-0.260	0.011	0.324	1		
X_8	0.951 ***	-0.575 ***	-0.577 ***	0.899 ***	0.501 **	0.554 ***	-0.641 ***	-0.697 ***	1	
X_9	0.736 ***	0.270	-0.690 ***	0.844 ***	0.440 **	0.331	-0.690 ***	-0.755 ***	0.807 ***	1

*Note: */ **/ *** indicates the existence of statistical significance at the 10%/ 5%/ 1% level, namely: *** indicates a probability ∈ [0; 0.01]; ** indicates a probability ∈ (0.01; 0.05]; * indicates a probability ∈ (0.05; 0.1].*

Source: Authors' computation in Stata 19.

According to the results in the table above, as expected, there is a strong positive and statistically significant correlation between per capita GDP (Y) and the independent variables: life expectancy at birth (X_3), employment (X_4), R&D expenditure (X_5), safely managed drinking water (X_8), and municipal waste recycling (X_9), while there is a strong negative and statistically significant correlation between GDP/inhabitant (Y) and the independent variables: poverty headcount (X_1), youth not in education/ employment (X_2), inflation (X_6), and GHG emissions (X_7).

Regarding the explanatory variables, we find that some pairs are weakly correlated (which is desirable), while other pairs show strong correlations (which raises multicollinearity issues). For example, there is a weak correlation between the variable X_1 and variables: X_2, X_5, X_6, X_7, and X_9

(correlation coefficient of 0.2 - 0.3); a medium correlation between the variable X_1 and variables: X_3, X_4, and X_8 (correlation coefficient of 0.4 - 0.5); a strong correlation between the variable X_9 and variables: X_3, X_7, and X_8 (correlation coefficient of 0.7 - 0.8). In this situation, to avoid the problem of multicollinearity, we will run several econometric models, each of which will integrate predictors that are not strongly correlated with each other, in order to obtain statistically consistent and unbiased results.

Given the results of the correlation matrix, we will estimate four regression models, each including a different set of explanatory variables, as follows: model 1 will include the variables: X_1, X_5, and X_9; model 2 will include the variables: X_2, X_3, and X_5; model 3 will include the variables: X_4, X_6, and X_7; and model 4 will include the variables: X_4, X_5, and X_8.

Furthermore, to confirm that there are no severe multicollinearity problems in the four models that we are going to estimate, table no. 4 encompasses the Variance Inflation Factor (VIF) test outcomes for each model. All VIF values are < 5, which indicates that all regressors are non-collinear and, therefore, are appropriate to be integrated into the same model.

Table no. 4. Variance inflation factor (VIF)

Model	Variables	VIF	1/VIF
Model 1	Poverty headcount (X_1)	1.20	0.8318
	R&D expenditure (X_5)	1.25	0.7987
	Municipal waste recycling (X_9)	1.16	0.8658
	VIF mean = 1.20		
Model 2	Youth not in education/employment (X_2)	1.75	0.5705
	Life expectancy at birth (X_3)	2.08	0.4809
	R&D expenditure (X_5)	1.35	0.7391
	VIF mean = 1.71		
Model 3	Employment (X_4)	1.07	0.9315
	Inflation (X_6)	1.12	0.8942
	GHG emissions (X_7)	1.20	0.8363
	VIF mean = 1.13		
Model 4	Employment (X_4)	1.41	0.6109
	R&D expenditure (X_5)	1.52	0.6575
	Safely managed drinking water (X_8)	1.64	0.7115
	VIF mean = 1.52		

Source: Authors' computation in Stata 19.

Another relevant aspect, before running the four regression models, is to check if residuals are serially correlated (i.e., the error in a period depends on the errors in the past periods). In this case, we apply the Breusch-Godfrey (BG) test, which has the advantage of detecting autocorrelation up to the order *p* (lag *p*) specified in the code. Since, in the present study, we have annual data and a small number of observations (only 25 observations), we test for autocorrelation of order 1 (lag 1) in the residuals. The results are highlighted in table no. 5. As noticed, in models 1 and 4, there is no serial correlation in the residuals (probability > 0.1), while in models 2 and 3, there is (probability < 0.1).

Table no. 5. Breusch-Godfrey (BG) test (dependent variable = GDP pc)

Model	Lags	Chi2	Degrees of freedom	Prob > chi2	Residuals are not serially correlated
Model 1	1	0.001	1	0.9734	True
Model 2	1	12.763	1	0.0004	False
Model 3	1	10.724	1	0.0011	False
Model 4	1	0.522	1	0.4698	True

Source: Authors' computation in Stata 19.

In addition, figure no. 4 shows the autocorrelation plot of the residuals for the first 10 lags, separately for each model. We checked the autocorrelation up to lag 10, because this threshold reflects approximately half of the analyzed period. However, given the annual nature of the data and the limited number of observations, it is of main interest to test the residuals' autocorrelation for the first and second lags. The plots confirm the BG test results: in models 1 and 4, the errors are independent from one period to another, while in models 2 and 3, there is autocorrelation of order 1, so the error at time t depends on the error at time $t-1$.

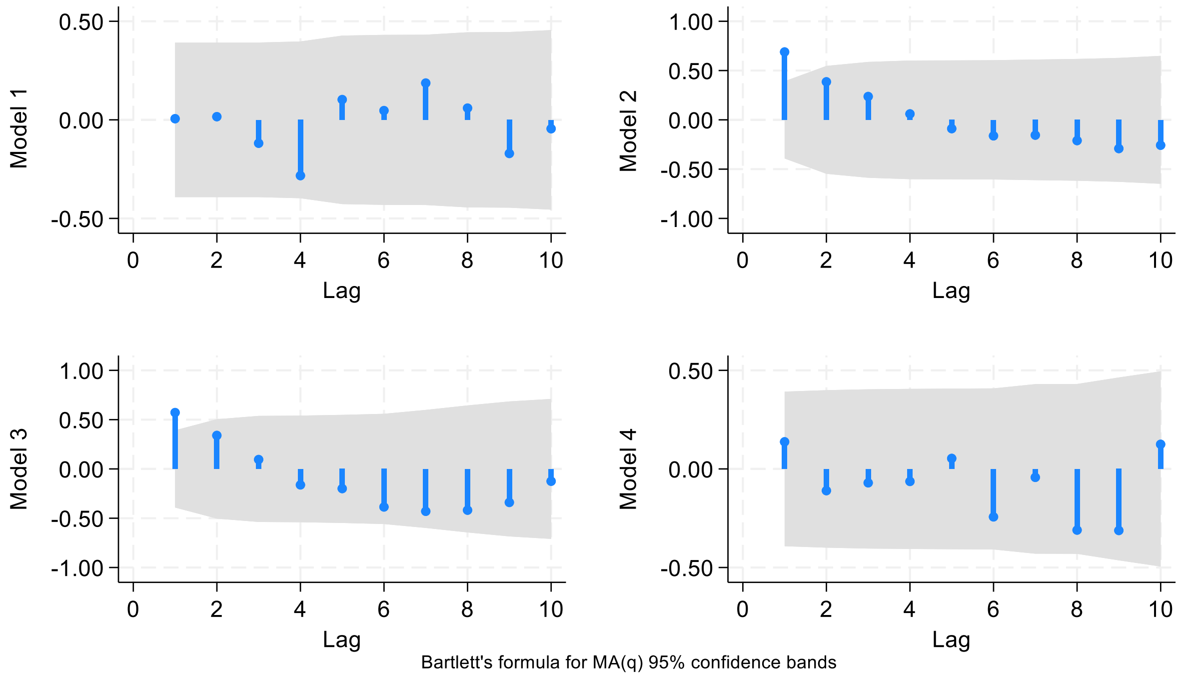

Figure no. 4. Autocorrelation of residuals up to lag 10 (dependent variable = GDP pc)

Source: Authors' computation in Stata 19.

In what follows, the results of the four models estimated through the OLS method with Newey-West standard errors are presented in table no. 6. For models 1 and 4, we set a zero-lag order of residuals correlation (according to the BG test, there is no serial autocorrelation), while for models 2 and 3, we applied a lag order of one.

Table no. 6. OLS models with Newey-West standard errors (dependent variable = GDP per capita)

Model	Variables	Coefficient	Newey–West standard error	P>|t|	[95% conf. interval]	
Model 1	Poverty headcount (X_1)	-0.441	0.099	0.000	-0.649	-0.234
	R&D expenditure (X_5)	0.287	0.074	0.001	0.133	0.440
	Municipal waste recycling (X_9)	0.522	0.086	0.000	0.343	0.700
	Intercept	-5.78e-06	0.077	1.000	-0.161	0.161
	F-statistic test (3, 21) = 64.94 (probability = 0.00) No. observations = 25					
Model 2	Youth not in education/ employment (X_2)	-0.019	0.110	0.863	-0.247	0.209
	Life expectancy at birth (X_3)	0.714	0.138	0.000	0.428	0.999
	R&D expenditure (X_5)	0.257	0.086	0.007	0.077	0.436
	Intercept	-7.09e-06	0.129	1.000	-0.269	0.269
	F-statistic test (3, 21) = 73.69 (probability = 0.00) No. observations = 25					
Model 3	Employment (X_4)	0.570	0.113	0.000	0.335	0.806
	Inflation (X_6)	-0.487	0.076	0.000	-0.644	-0.330

	GHG emissions (X_7)	-0.282	0.126	0.037	-0.545	-0.019
	Intercept	9.98e-07	0.106	1.000	-0.220	0.220
	F-statistic test (3, 21) = 39.94 (probability = 0.00) No. observations = 25					
Model 4	Employment (X_4)	0.239	0.089	0.014	0.054	0.425
	R&D expenditure (X_5)	0.088	0.044	0.058	-0.003	0.180
	Safely managed drinking water (X_8)	0.782	0.049	0.000	0.681	0.883
	Intercept	-4.96e-06	0.043	1.000	-0.089	0.089
	F-statistic test (3, 21) = 268.63 (probability = 0.00) No. observations = 25					

Source: Authors' computation in Stata 19.

Starting from equation 2, in accordance with the results obtained in the four models estimated above, the linear multifactorial regression equations can be expressed as follows:

Model 1: $\widehat{GDP_{pc}} = -0.441 * X_1 + 0.287 * X_5 + 0.522 * X_9 + 0{,}000 * Intercept$ (3)
Model 2: $\widehat{GDP_{pc}} = -0.019 * X_2 + 0.714 * X_3 + 0.257 * X_5 + 0{,}000 * Intercept$ (4)
Model 3: $\widehat{GDP_{pc}} = 0.570 * X_4 - 0.487 * X_6 - 0.282 * X_7 + 0{,}000 * Intercept$ (5)
Model 4: $\widehat{GDP_{pc}} = 0.239 * X_4 + 0.088 * X_5 + 0.782 * X_8 + 0{,}000 * Intercept$ (6)

In the following, we will provide a detailed interpretation of each model.

Model 1: all variables involved in the first model are statistically significant at the 1% level (probability < 0.01). Regarding the influence, it is observed that the predictors R&D expenditure (X_5) and municipal waste recycling (X_9) exert a positive effect (coefficients of 0.287 and 0.522, respectively) on economic development in Romania, during the period 2000-2024, while the variable poverty headcount (X_1) has a negative impact (coefficient of -0.441). More precisely, a one-standard-deviation increase in *(i)* R&D spending and *(ii)* waste recycling, respectively, induces an increase of *(i)* 0.287 and *(ii)* 0.522 standard deviations of GDP per capita. One explanation for the beneficial effect of R&D spending on economic growth and development lies in the fact that financial resources channeled to R&D sectors pave the way for increasing the innovation capacity of a state, stimulating long-term productivity and competitiveness within domestic industries (Saman, 2022). As regards waste recycling, it plays a key role in lessening natural resource consumption, spurring overall resource efficiency, and contributing significantly to the transition to a circular economy, all of which stimulate economic development (Robaina et al., 2020). In contrast, an increase of one standard deviation in the number of people at risk of social poverty leads to a decrease in GDP per capita by 0.441 standard deviations. This is because poverty and shortcomings prevent people from leading healthy lives, diminish school enrollment, and inhibit citizens from developing cognitively and reaching their full potential (European Youth Forum, 2013). Hence, long-term economic development is hindered.

Model 2: variables life expectancy at birth (X_3) and R&D expenditure (X_5) are statistically significant at the 1% level (probability < 0.01), while youth not in education/ employment (X_2) is not statistically significant (probability > 0.1). More precisely, both X_3 and X_5 have a positive and relevant impact on economic development: a one-standard-deviation increase in these regressors causes an increase of 0.714 and 0.257 standard deviations, respectively, in GDP per capita. Concerning X_2, although it is statistically insignificant, the sign of the estimated coefficient is the expected one (coefficient of -0.019). Thus, the higher the proportion of young people who are not in the education system, are not employed, or are not following a vocational training program, the more likely it is that economic development in Romania will slow down.

Model 3: the employment rate (X_4) has a positive effect on economic development, being statistically significant at the 1% level (probability < 0.01). A one-standard-deviation increase in the rate of people with a stable job induces an increase of 0.570 standard deviations in GDP/capita. Employment involves people with stable workplaces and incomes, which translates into an increased ability of households to consume, save, or spend, a poverty-diminishing, and, therefore, an improvement in the individuals' general well-being and the country's economic health (Haider et al., 2023). In contrast, an increase in inflation (coefficient of -0.487, statistically significant at the 1% level) and in total annual greenhouse gas emissions per capita (coefficient of -0.282, statistically significant at the 5% level) lead to a decrease in GDP/capita. The reason for these results could be that inflation, which reflects a decrease in the purchasing power of money, causes a reduction in population consumption, fuels the sentiment of uncertainty for the future, and makes investments less desirable (Ivory Research, 2019). Furthermore, the negative impact of pollutants can be explained by the fact that they affect the population's health, which subsequently leads to reduced work capacity, decreased productivity, and, in extreme cases, to the inability to participate in the labor market, all of which ultimately contribute to the slowdown of economic activity (Zivin & Neidell, 2012).

Model 4: employment rate (X_4) is statistically significant at a 5% level, expenditure on R&D (X_5) is significant at a 10% level, and the percentage of people using safely managed water supply services (X_8) is significant at a 1% level. All these predictors induce positive effects on economic performance, i.e., a one-standard-deviation increase in the above-mentioned variables determines an increase of *(i)* 0.239, *(ii)* 0.088, and *(iii)* 0.782 standard deviations in real GDP per capita.

According to the econometric results obtained, we draw the following straightforward conclusions, which answer our initial research question. First, the impact of all variables on GDP/ inhabitant is in line with both our initial assumptions and the findings of other researchers (refer to Dragoescu, 2015; Goschin, 2015; Ignat et al., 2015; Adrangi & Kerr, 2022; Zhu et al., 2022). More specifically, life expectancy at birth (X_3), employment (X_4), R&D expenditure (X_5), safely managed drinking water (X_8), and municipal waste recycling (X_9) have a positive effect on GDP per capita, while poverty headcount (X_1), youth not in education/ employment (X_2), inflation (X_6), and GHG emissions (X_7) exert a negative effect. Second, all regressors are statistically significant at the 1%, 5%, or 10% levels, except for X_2. Nevertheless, although the coefficient of X_2 has a probability > 0.1, at least its sign is the expected one. Third, in all four models, the probability of the F-statistic test (a statistical test for examining the regression's overall significance) is lower than 0.01, which denotes that the independent variables are relevant in explaining the evolution of GDP per capita during 2000-2024, for the case of Romania. In other words, each regression model fits the data better than the model based on the intercept alone.

5. Robustness check

A salient question regarding the stability and reliability of the results obtained is whether they remain consistent if a different proxy variable is used to describe the economic development concept. Therefore, in an endeavor to appraise the robustness of our results, in the following, we run the same OLS models with Newey-West standard errors, but instead of real GDP per capita, we use the Human Development Index (HDI) introduced by the United Nations Development Programme. HDI integrates three dimensions: *(i)* a healthy and long life (dimension assessed by birth life expectancy), *(ii)* knowledge (dimension assessed by the average as well as the expected number of schooling years), and *(iii)* a decent living standard (dimension assessed by per capita gross national income) (UNDP, 2025). HDI is expressed in scores $\in [0,1]$, these scores having the following interpretation: a low value indicates a low human development level, while a high value unveils a high human development level (UNDP, 2025). Given that we standardized all independent variables, we considered it appropriate to also calculate Z-scores for HDI to ensure data comparability.

Before running the OLS models, we check for serial correlation in errors, as we also did for the models where the dependent variable was GDP per capita. Thus, for each model, in figure no. 5, we have illustrated the autocorrelation graph of the residuals up to lag 10, with HDI being the dependent variable. We note that only in model 1 are the errors independent from one year to another, while in the other three models, there is autocorrelation of order 1 (for these, we will use the lag of order 1 in the model specification).

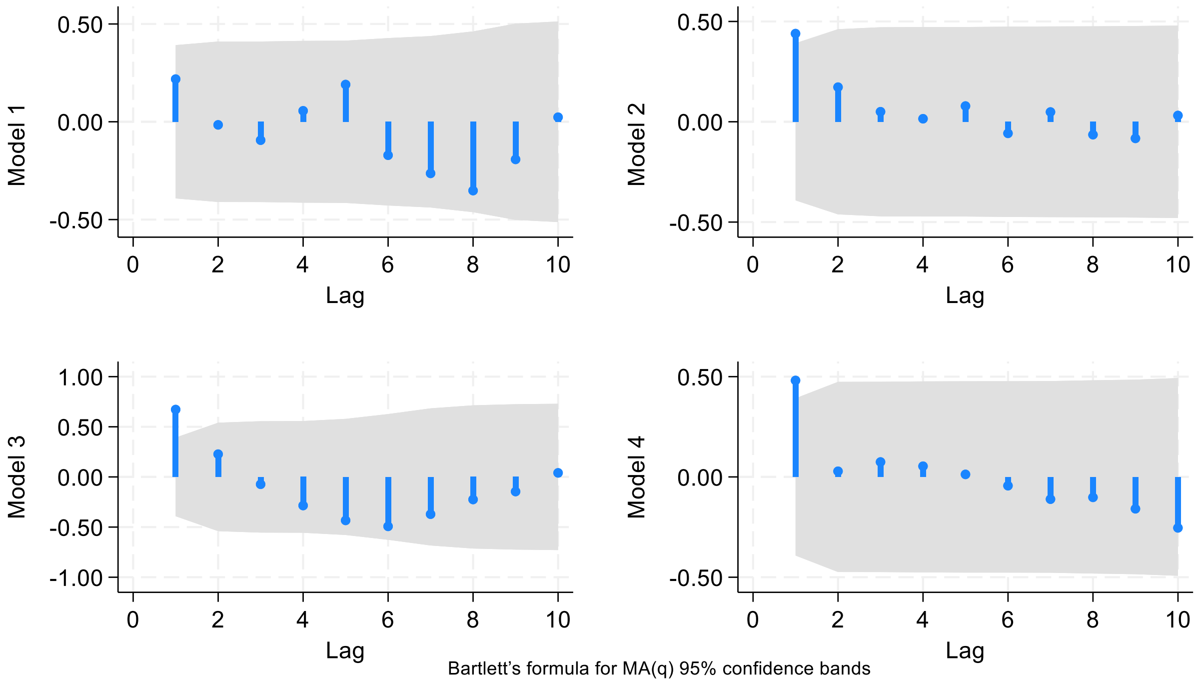

Figure no. 5. Autocorrelation of residuals up to lag 10 (dependent variable = HDI)
Source: Authors' computation in Stata 19.

Table no. 7 presents the results of the four models estimated using the OLS method with Newey-West standard errors, in which economic development is proxied by the HDI. It is important to note that in model 2, we eliminated the variable life expectancy at birth (X_3) because this is one of the HDI components.

The results might be summarized as follows: *(i)* all predictors show statistical significance at 1%, 5%, or 10% levels, with the exception of poverty headcount (X_1) and employment (X_4), whose coefficients have a probability value slightly close to the 10% significance threshold; *(ii)* the impact of all explanatory variables on the response variable is in accordance with our prior expectations. Therefore, the HDI is positively influenced by the employed population (X_4), R&D spending (X_5), the inhabitants' access to safely managed drinking water (X_8), as well as waste recycling (X_9). Conversely, it is negatively influenced by people living in poverty (X_1), young people who are neither in education nor employed (X_2), inflation (X_6), and greenhouse gas emissions (X_7).

Table no. 7. OLS models with Newey-West standard errors (dependent variable = HDI)

Model	Variables	Coefficient	Newey–West standard error	P>|t|	[95% conf. interval]	
Model 1	Poverty headcount (X_1)	-0.114	0.070	0.118	-0.259	0.031
	R&D expenditure (X_5)	0.425	0.079	0.000	0.261	0.589
	Municipal waste recycling (X_9)	0.618	0.114	0.000	0.382	0.854
	Intercept	-4.46e-06	0.089	1.000	-0.186	0.186
	F-statistic test (3, 21) = 38.15 (probability = 0.00) No. observations = 25					

Model 2	Youth not in education/ employment (X_2)	-0.388	0.150	0.017	-0.700	-0.077
	R&D expenditure (X_5)	0.538	0.244	0.038	0.031	1.044
	Intercept	-8.65e-06	0.161	1.000	-0.334	0.334
	F-statistic test (3, 22) = 39.21 (probability = 0.00) No. observations = 25					
Model 3	Employment (X_4)	0.280	0.104	0.013	0.065	0.496
	Inflation (X_6)	-0.716	0.055	0.000	-0.831	-0.601
	GHG emissions (X_7)	-0.258	0.139	0.078	-0.548	0.032
	Intercept	3.71e-06	0.112	1.000	-0.233	0.233
	F-statistic test (3, 21) = 87.99 (probability = 0.00) No. observations = 25					
Model 4	Employment (X_4)	-0.158	0.093	0.104	-0.352	0.035
	R&D expenditure (X_5)	0.274	0.095	0.009	0.076	0.472
	Safely managed drinking water (X_8)	0.846	0.135	0.000	0.566	1.127
	Intercept	-3.36e-06	0.082	1.000	-0.170	0.170
	F-statistic test (3, 21) = 32.22 (probability = 0.00) No. observations = 25					

Source: Authors' computation in Stata 19.

Overall, we may state that the econometric estimates in this study are robust, not changing significantly if alternative proxies are introduced. Finally, we mention that the results obtained in the present research are consistent with those obtained by various scholars who have addressed the topic of economic development both in Romania and internationally (for example, Costea et al., 2012; Oţil et al., 2015; Ioan et al., 2024; Pavelescu & Dumitru, 2025).

6. Conclusions

The main objective of the present research was to assess the impact of various economic, social, and environmental factors on economic development at the Romanian level, during the period from 2000 to 2024. In this respect, we first proxied economic development through GDP per capita (a core economic performance indicator), and then, to validate the robustness of the results, we used HDI (a human well-being indicator). Regarding econometric estimation, we applied the OLS model with Newey-West standard errors to four models (each with uncorrelated regressors). The econometric results are mostly statistically significant at the level of 1%, 5%, or 10%, and unveil: *(i)* a positive effect of the employed labor force, R&D expenditure, access to drinking water from an improved source, and municipal waste recycling on GDP/capita, *(ii)* a negative effect of individuals experiencing poverty, youth that are neither studying nor working, inflation, and GHG emissions on GDP/capita. These outcomes align with our preliminary expectations, as well as the existing scientific literature on economic development. Finally, the robustness check part confirms the reliability of our findings.

Regarding the limitations of this research, they come from the following aspects. First, we have a small number of observations (only 25), because the econometric analysis was carried out on Romania (1 unit), for the period between 2000 and 2024 (25 years). However, this was due to the lack of data for certain variables for the years prior to 2000. Second, we analyzed the influence of exogenous variables on economic development exclusively from a static perspective, not a dynamic one. Nevertheless, the reason for this choice was that, in a dynamic model, due to the use of the lagged variables, observations are lost (a case which we sought to avoid). Third, there is a potential endogeneity between the dependent and independent variables, which could have been addressed if dynamic models were involved.

As for possible future research directions, we mention adding other explanatory variables to the model. For instance, one could include a dummy variable to capture exogenous shocks to the economy, such as the 2007-2009 global financial crisis, the pandemic of COVID-19, or Russia's war against Ukraine. Also, more advanced econometric models, which have the capacity to correct for the endogeneity problem and address the autoregressive nature of the dependent variable, could be employed.

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