



# Development of a Numerical Regression Model of Gross Domestic Product per Capita Movement in the European Union Member State as a Result of Investments in R&D from the Structural Funds

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## ABSTRACT

This paper examines the movement of gross domestic product per capita (GDP per capita) depending on the normalized value of financial incentives in the field of research and development in the EU-28 Member States. It determines the type of dependence of these variables in the period 2014-2019, evidenced by the Pearson correlation coefficient. Based on empirical data, a mathematical model is formulated that predicts the dynamics of GDP growth in the forthcoming financial perspective 2021-2027 in regard to drawing EU funds.

**Keywords:** European Structural Funds, R&D Projects, Co-financing, GDP Per Capita

**JEL Classifications:** E02, E17, F45, O30

## 1. INTRODUCTION

The objective of the EU cohesion policy, which accounts for a third of the EU's total budget, is to eliminate development disparities between regions. The main tool for achieving this goal is the legal framework of the European Structural Funds that promote innovation, knowledge, and technological progress. The Structural Funds follow certain EU priorities in directing funding into the different regions. In the 2014-2020 financial perspective, the predominant weight is placed on investment in research, technological development, and innovation (R&D).

47.24% of the funds are allocated for the development of ideas from TRL 3 to TRL 9 (HORIZON, 2020); ideas based on knowledge and innovation that will bring new jobs. The need for R&D investments is implemented through the scoreboards of

centralized and decentralized public tenders - more than half of the weights are on the R&D side (Table 1).

The Structural Funds provide an additional source of revenue for the implementation of R&D projects in Member States or regions of the EU that are lagging in development. The purpose of this paper is to determine whether the selection of R&D projects is effective, sustainable, and economically feasible. This paper will thus explore the extent to which selected R&D projects affect the EU economy. An analysis of the link between the Cohesion Policy funding and R&D and its economic impact on GDP<sub>percapita</sub> will be carried out.

This research has the following two hypotheses:

- The federal growth of the GDP<sub>percapita</sub> indicator is the result of co-financing of R&D projects.
- The dynamics of the GDP<sub>percapita</sub> indicator can be predicted based on the envisaged co-financing of R&D projects from the European Structural Funds.

## 2. LITERATURE REVIEW

Cohesion policy is the EU’s main investment policy. It provides many opportunities to fund breakthrough, sustainable projects, it supports job creation, business competitiveness, and a low-carbon society. The EU is putting pressure on economies to boost R&D investments. The Structural Funds direct their resources towards priority objectives that reflect cohesion policy priorities and are the basis for deciding which research and development projects should be supported (Požarnik and Robič Mohar, 2018).

The main cohesion policy funds for co-financing R&D projects are (European Structural and Investment Funds 2014-2020, European Commission):

- 1) The European Regional Development Fund (ERDF), thematically focused on innovation and research, the Digital Agenda, support for small and medium-sized enterprises (SMEs) and the low-carbon economy, and
- 2) The European Agricultural Fund for Rural Development (EAFRD), thematically focused on increasing the competitiveness of agriculture, ensuring sustainable management of natural resources, achieving balanced territorial development, including creation and maintenance of employment opportunities.

Financial support would go to projects, which will raise the level of economic activity, improve the competitiveness of the economy, strengthen human potential and forward new research, technological and innovative knowledge (Požarnik and Robič Mohar, 2015).

Cohesion policy provides the necessary investment framework and strategy to achieve the growth goals within the priority areas of the Europe 2020 Strategy. There are five goals that define the expected achievements of the EU by 2020 in the most important areas. In the 7-year period 2014-2020, € 432 billion

are reserved for the fund, of which € 68 billion are allocated exclusively for the thematic area Research and Innovation. The European Union is addressing economic and social disparities in development between Member States’ regions through financial incentives. The main investment policy of the established economic and political integration of the 28 countries uses a solidarity approach, using development activities, programs and measures coordinated and co-financed by the EU. Most of the funds are allocated to less developed European countries and regions to catch up with the rest as soon as possible and to reduce economic, social, and territorial disparities (Cini and Perez-Solorzano Borragan, 2016, Hix and Høyland, 1999, Wallace et al., 2010).

The concept of smart specialization has been developed to strengthen the R&D capacity of national and regional actors and to achieve the objectives in less developed regions. It is the main driver of the “Innovation Union” initiative, as well as the reform of cohesion policy in the field of innovation. The developed concept offers numerous advantages, but at the same time allows for a diverse evolutionary nature (Cini and Perez-Solorzano Borragan, 2016, McCann and Ortega-Argilés, 2013).

The allocation of funds is based on the classification of regions. This classification is based on the Standard Classification of Territorial Units (NUTS). The use of the classification enables collecting, development and dissemination of harmonized regional statistics within the European Union, and also serves for the socio-economic analysis of regions.

The criterion for determining specific conditions for eligibility for Structural Funds is the GDP<sub>percapita</sub> indicator. It defines the classification of EU regions at level 2 (NUTS 2) according to the common classification of statistical territorial units into three categories (Regulation (EU) No 1303/2013).

**Table 1: Review of point weights in the scoreboards of centralized and decentralized public tenders**

Type of tender	Tender	Tendered	Number of points (total)	Number of points (R&D field)	Weight R&D
Centralized	Fast Track to Innovation (FTI)	European Commission	15	10	66.7%
Centralized	Next Generation Internet of Things	European Commission	15	10	66.7%
Centralized	Enhancing IP4 Ecosystem	European Commission	15	10	66.7%
Decentralized	Incentives for research and development projects 2	MGRT (Ministry of Economic Development and Technology, Slovenia)	150	90	60.0%
Decentralized	Incentives for SMEs to develop and introduce new products in wood industry 3.0	MGRT (Ministry of Economic Development and Technology, Slovenia)	100	61	61.0%
Decentralized	5th public tender for sub-measure 4.2 - Support for investments in processing, marketing or development of agricultural products for 2019	MKGP (Ministry of Agriculture, Forestry and Food, Slovenia)	100	55	55.0%
Decentralized	Increasing the development of new products and services arising from research and development activities - phase II	MINGO (Ministry of Economy, Entrepreneurship and Crafts, Croatia)	100	65	65.0%
Decentralized	Development and competence upgrade of SMEs	MINGO (Ministry of Economy, Entrepreneurship and Crafts, Croatia)	100	55	55.0%

### 3. DATA AND ESTIMATION TECHNIQUES

#### 3.1. Data

To determine parameters of the mathematical model, the data set of the annual average value of the GDP<sub>percapita</sub> indicator and the total value of the V<sub>RD</sub> in the period 2014-2019 was considered, as shown in Table 2.

Development studies of both observed variables of the mathematical model in the time interval 2014-2019 were performed by using IBM® SPSS® Statistics.

#### 3.2. Model Specification

As a solution to the challenge, the research part of this paper presents an analysis of GDP<sub>percapita</sub> dynamics, analysis of the numerical and graphical data and definition of a mathematical model of the regression function (Pearson correlation, linear regression model) (Chen and Popovich, 2002, Sharma, 2012, Bredin and Fountas, 2009).

The method of studying variables was used in the preparation of this research. The performed dynamics analysis is based on the expenditure method of measuring the GDP<sub>percapita</sub> indicator. The indicator is defined as a ratio between the sum of the four

groups of expenditure and the population of the analysed country. According to this method, GDP<sub>percapita</sub> is defined as (Anghelache, 2009, Goodwin, 2008).

$$GDP_{percapita} = \frac{P+G+I+NE}{pop} \tag{1}$$

Where the following is considered:

- P = Private consumption
- G = Government spending
- I = Investments
- NE = net exports (export - import)
- pop = No. of population in the country.

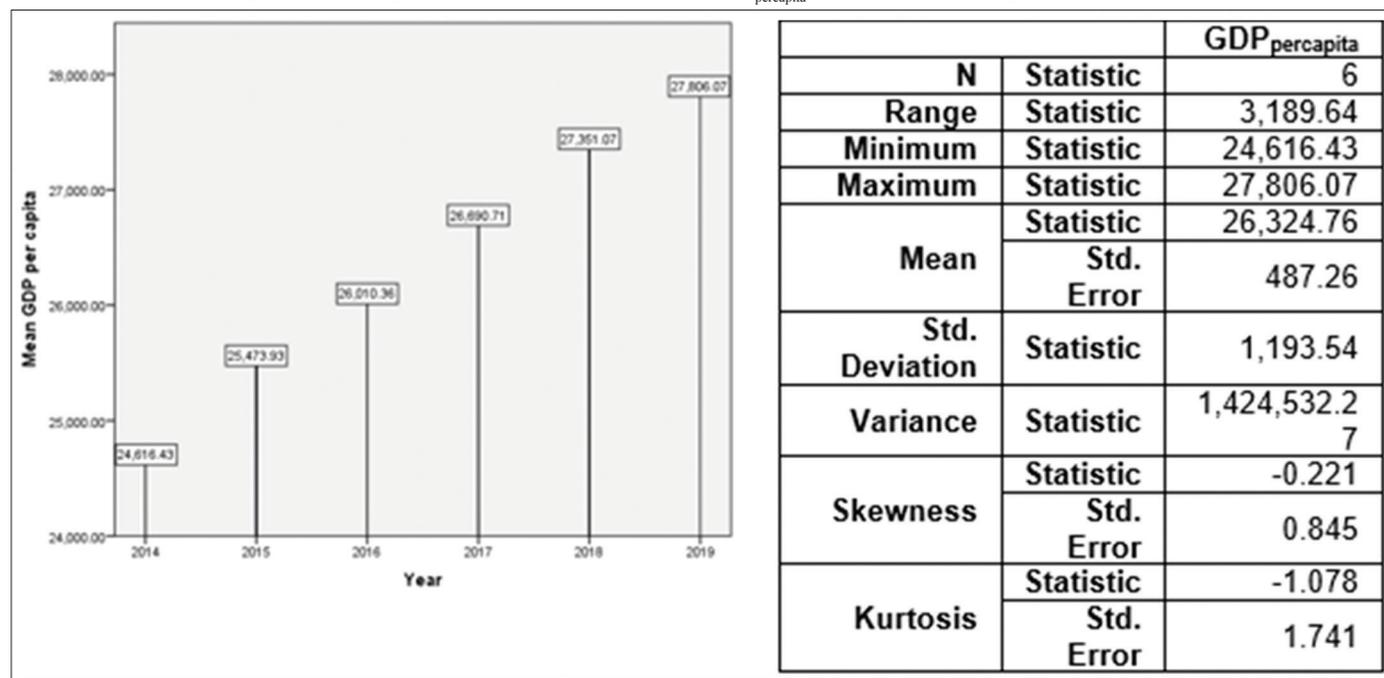
The observation point is set on the element of the GDP<sub>percapita</sub> I (investment) indicator. The other elements of Equation 1 are considered to be constant. A regression model was used, defined on the basis of the previously mentioned assumptions, according to the methodology of variables. The GDP<sub>percapita</sub> indicator is presented as a dependent variable, and the value of EU financial incentives for R&D projects per capita (hereinafter referred to as V<sub>RD</sub>) as an independent variable.

The following mathematical model is defined for the creation of a linear regression model:

**Table 2: Presentation of baseline data for research (Fact Sheets on the European Union, European Commission, Eurostat)**

Year	No. of inhabitants	GDP <sub>percapita</sub> (v EUR)	Value of EU co-financing of R&D projects (total, in EUR)	V <sub>RD</sub> (in EUR)
2014	507,235,091	24,616.43	157,217.07	0.00
2015	508,520,205	25,473.93	126,644,032.25	0.25
2016	510,181,874	26,010.36	879,618,292.67	1.72
2017	511,378,572	26,690.71	3,752,767,021.28	7.34
2018	512,372,000	27,351.07	6,543,930,560.25	12.77
2019	513,471,676	27,806.07	7,173,984,268.29	13.97
TOTAL			18,477,101,391.81	36.06

**Figure 1:** Development of the value of the annual GDP<sub>percapita</sub> indicator in the time period 2014-2019



$$GDP_{percapita} = k * V_{RD} + n \tag{2}$$

Where the following applies:

$V_{RD}$  = value of EU financial incentives for R&D projects per capita  
 $K, n$  = regression coefficient

### 4. EMPIRICAL RESULTS

As can be seen from the data analysis (Figure 1), the  $GDP_{percapita}$  indicator recorded a constant increase in the time period under consideration. This is the result of a favourable economic environment, which was not marked by major financial or international crises during this period. With help of the statistical program, a series of statistical tests were performed, which give a more precise definition of the dependent variable under consideration. The average value of the  $GDP_{percapita}$  indicator for the time period 2014-2019 amounts to EUR 26,324.76. The lowest value of the indicator is EUR 24,616.43 (2014) and reaches a maximum value of 27,806.07 in 2019. The distribution of data in the observed time period is asymmetric, the symmetry coefficient is  $-0.221$ . The flattening coefficient (kurtosis) is  $-1.078$ .

A similar analysis was performed by observing the development of  $V_{RD}$  values in the time period 2014 - 2019. The data are presented in Figure 2.

The conclusion of the graphic presentation is that the inflows of co-financed R&D projects in the EU do not occur until 3 years after the start of the financial perspective. Prior to that, co-financing was realized to a much lesser extent and represents only 5% of all realized financial incentives. Based on a statistical

analysis, it is established that co-financing of R&D projects in the EU-28 countries amounts to EUR 36.05 per capita. The average value of the time period 2014-2019 is EUR 6.01 per capita. The distribution of data on the observed interval is asymmetric, the symmetry coefficient is 0.395. The flatness coefficient (kurtosis) is  $-2.319$ .

The result of the performed analyses is that the model of development of both variables is very similar - the interval of analysed data records a constant increase. There is also a noticeable similarity of the statistical tests performed for the set of observed data. Based on these findings, we claim that there is an important correlation between the value of the  $GDP_{percapita}$  indicator and the value of the  $V_{RD}$ . The federal growth of the  $GDP_{percapita}$  indicator is the result of co-financing of R&D projects. To confirm this hypothesis, a graph is generated showing pairs of values for each year of the observed period.

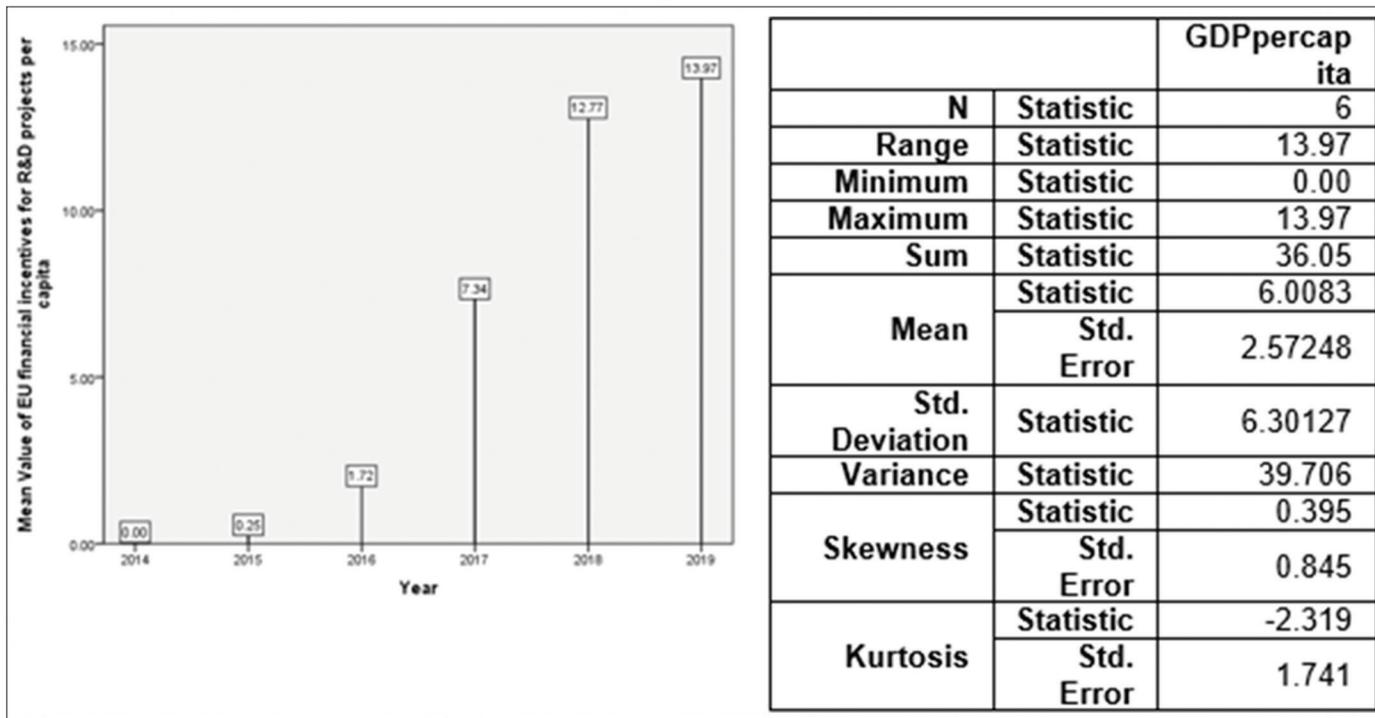
As can be seen from Figure 3, the pairs form a coordinated line that provides a qualitative starting point for determining the regression model of both variables by the linear regression method. The value of the correlation coefficient between the two variables is 0.950, which proves that there is a strong positive linear correlation. Other parameters of the regression model are defined with the statistical program IBM® SPSS® Statistics (Figure 4).

Based on the results, the linear regression model is defined as:

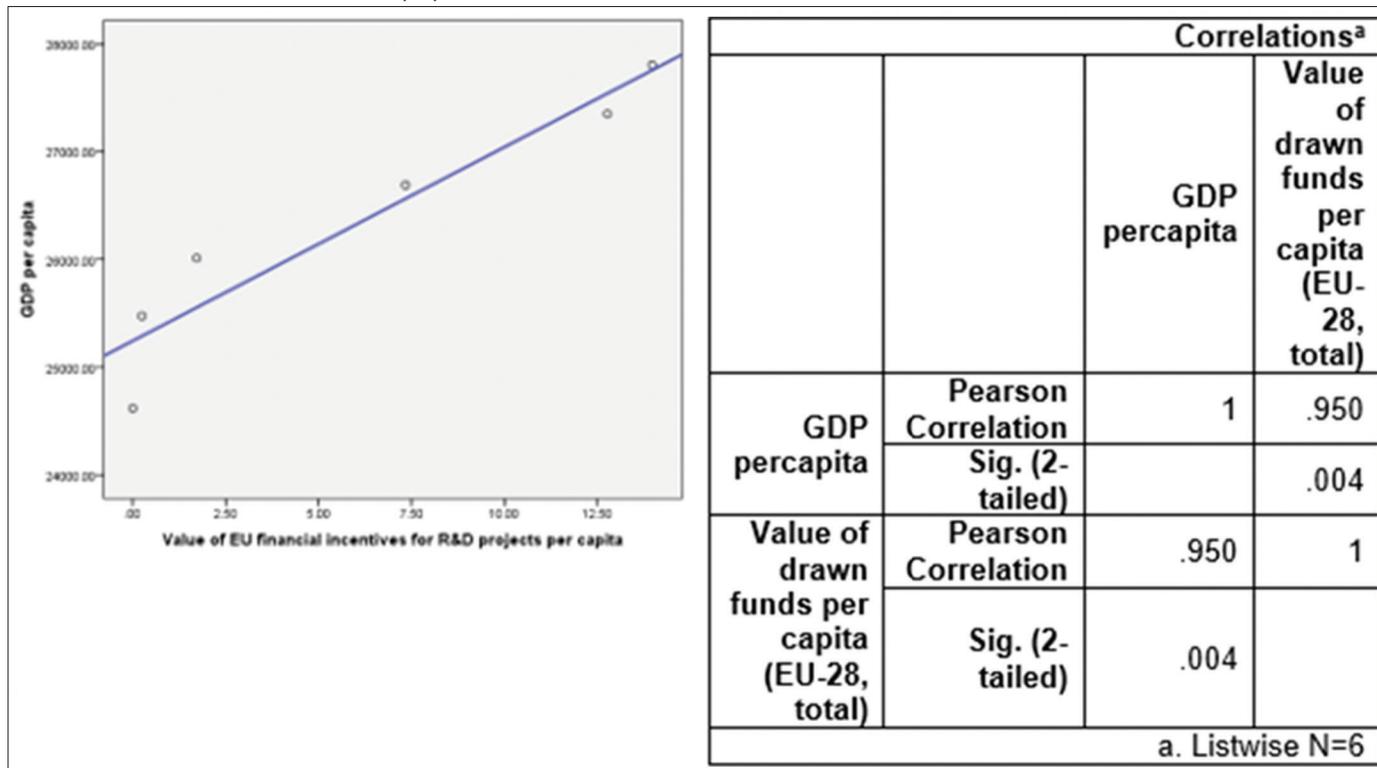
$$GDP_{percapita} = 179.99 * V_{RD} + 25,243.35 \tag{3}$$

with a very high probability of model correctness ( $R=0.950$ ).

Figure 2: Development of  $V_{RD}$  value in the time period 2014-2019



**Figure 3:** Pairs of GDP<sub>percapita</sub> and V<sub>RD</sub> values for each year of the observed time period, correlation coefficient



**Figure 4:** Results of statistical analysis to determine the regression model

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Model Summary Change Statistics					
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.950 <sup>a</sup>	.903	.879	415.74015	.903	37.210	1	4	.004	
a. Predictors: (Constant), Value of EU financial incentives for R&D projects per capita										
ANOVA <sup>a</sup>										
Model	Sum of Squares	df	Mean Square	F	Sig.					
1	Regression	6431301.878	1	6431301.878	37.210	.004 <sup>b</sup>				
	Residual	691359.494	4	172839.874						
	Total	7122661.372	5							
a. Dependent Variable: GDP per capita										
b. Predictors: (Constant), Value of EU financial incentives for R&D projects per capita										
Coefficients <sup>a</sup>										
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.				
		B	Std. Error	Beta						
1	(Constant)	25243.351	245.429		102.854	.000				
	Value of EU financial incentives for R&D projects per capita	179.985	29.506	.950	6.100	.004				
a. Dependent Variable: GDP per capita										

### 5. CONCLUDING REMARKS

In this research paper it has been proven that there is a strong correlation between the federal growth of the GDP<sub>percapita</sub> indicator and the V<sub>RD</sub> value. The analysis of the graphs proves that the distribution of the collected information for both variables is quite similar. It has been noted that there is a time lag in drawing financial incentives for development and research projects. The reason for the occurrence of time delays are e.g. delays in publishing tenders

or exceeding the deadlines for project selection procedures. The delays in successful draws of the European Union’s financial incentives also lead to a delay in planned spending in later years, which causes risks to lose funds.

A regression model has been defined, which enables us to determine the dynamics of the GDP<sub>percapita</sub> indicator in relation to the anticipated amount of co-financing of R&D projects per capita. There is a significant relationship between the variables - increasing

the value of  $V_{RD}$  by 1 unit will consequently increase the value of  $GDP_{percapita}$  by 179.99 units.

Although the impact of R&D investment is an important part of the  $GDP_{percapita}$  indicator, the question of a system of indicators that further clarify the importance of R&D investment at EU or Member State level remains open. A topic for further research is the ranking of the impact of various areas (e.g. agriculture, infrastructure, rural development, cross-border cooperation and integration, social inclusion, transport, environment, and space) on the dynamics of  $GDP_{percapita}$ .

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