ANALYSIS OF THE RELATIONSHIP BETWEEN INNOVATION AND PERFORMANCE. THE CASE OF ROMANIA VERSUS THE COUNTRIES OF WESTERN EUROPE

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Abstract: The research paper consists in analyzing the relationship between investments in innovation and macroeconomic performance indicators. Recent scientific literature argues that investment in innovation has a direct and positive impact on the performance of an economy. This paper aims to analyze the existence of the link between innovation and performance efforts as well as the analysis of their intensity both in Western European countries and in Romania. The data needed to assess investment in innovation, as well as those related to countries' macroeconomic performance, were selected from both the World Bank website and the OECD website for the period 1991-2018. The research method used involves the analysis of data using regression and correlation, which are calculated using the statistical program SPSS. The study argues that investments in innovation activities can have a positive influence on macroeconomic performance indicators.

JEL classification: O3, O1, O4

Key words: innovation; performance; Romania; Western Europe; regression; correlation

1. INTRODUCTION

Innovation is the process of creating a new technological process, a new product or service, creating an organization or improving existing products, services, technological processes or organizations (Gerguri, Shqipe & Ramadani, Veland, 2010).

In the literature, the relationship between investment in innovation and economic growth is intensively researched and is a topic of interest to academia, with authors supporting this link and authors denying the existence of a positive or direct link between the two.

In order to achieve the research objectives, we have included in the second section, works from the specialized literature that test this connection. The third section, which presents the research methodology, mentions the purpose, objectives and hypotheses of the research, detailing the analyzed variables, the data source and the proposed econometric models. The fourth section discusses the results obtained and the conclusions in which the contributions and limits of the research are summarized.

2. OBJECTIVES

This study aims to perform a detailed analysis of the relationship between innovation and macroeconomic performance, both in Romania and in Western European countries, respectively Austria, Belgium, France, Germany and the Netherlands, using both growth variables and economic variables. innovation.

In this paper, both a correlation analysis and a regression analysis are presented, in which the impact of innovation on economic growth is observed.

3. REVIEW OF THE SCIENTIFIC LITERATURE

In the opinion of Kayacan and Bektaş (2015, pp. 502) „R&D spending is considered an investment in new technologies and knowledge, which can then be transformed into more efficient production methods in relation to available resources. The higher the research and development expenditures, the higher the economic growth."

(Pala, A., et al., 2019), analyzes the impact of technological development on macroeconomic performance in 25 developing countries in the period 1996-2016, using the random coefficient (RCM) for their selection. „The variables used in the study were innovation variables the number of scientific and technical articles, the number of employees in research and development departments, the number of patents and research and development expenditures", as well as several macroeconomic indicators to analyze performance.

The conclusions of the study refer to the fact that the results differ from one country to another, confirming an insignificant effect of research and development expenditures on growth indicators in countries such as China, Egypt, Iran, Moldova, Panama, Serbia and Uzbekistan. The number of researchers has an insignificant effect on economic growth in Iran, Mexico, Tunisia, Uzbekistan and a positive effect in Ukraine, Turkey, Russia and China.

The study conducted by (Maradana, R.P. et al., 2017) examines the long-term relationship between innovation and growth in 19 European countries in the period 1989-2014. It uses six different indicators of innovation: residents 'patent applications, non-residents' patent applications, research and development expenditures, researchers in research and development, high-tech exports and articles in scientific and technical journals as independent variables, and gross domestic product per capita as a dependent variable. The study provides mixed evidence on the relationship between innovation and economic growth per capita in the 19 European countries, both at the level of each country and at the group level of countries, in some cases innovation having a strong impact on economic growth and in others a weak influence.

(Pece, A.M., Oros, S.O.E., and Salisteanu, F., et al., 2015), analyzes the impact of an economy's innovation potential on long-term economic growth. The analysis was performed using several regression models estimated for the following EEC countries, namely Poland, the Czech Republic and Hungary.

The authors used in their study as variables the research and development expenses, the number of trademarks and the number of patents. The study showed that the relationship between macroeconomic performance and innovation is a positive one.

The study conducted by (Tuna, K., Kayacan, E. and Bektaş, H., 2015) analyzes the relationship between research and development expenditures and indicators of macroeconomic performance in the case of Turkey, arguing that this relationship is not a long-term one.

Another study by researchers (Phirouzabadi, A., M., and Nikzad, N.,) in 2014 analyzes the relationship between patent applications for residents and non-residents and gross domestic product.

They concluded that in economically developed countries there is a strong link between patent applications for residents and non-residents and gross domestic product.

(Bozkurt, C., et al., 2015) states that countries that allocate more resources to research and development are developed countries with a high level of income. The results of studies in the literature show that innovation does not always have a strong effect on economic growth, it depends largely on the level of development of an economy and the resources allocated to research.

4. METHODOLOGY

The present paper aims to analyze the link between innovation variables and economic growth using correlation and regression analysis as statistical methods of analysis. The study is carried out both in Romania and in five Western European countries, namely Austria, Belgium, France, Germany and the Netherlands.

The data analyzed in this study consist of the number of patent applications for residents (PAR), the number of patent applications for non-residents (PAN), gross development research (R&D) expenditures, the number of researchers per 1000 employees (R 1000) these being independent variables and the gross domestic product per capita (GDP per capita) in absolute values, this being the variable dependent on the model in the regression analysis. These data are analyzed for the period 1991-2018.

We chose to analyze Romania and Western European countries due to their position in the EIS (European Innovation Scoreboard) ranking, including countries from three categories of innovative countries, namely modest innovators, strong innovators and leaders in innovation.

Analyzing the impact of the four independent variables, we can observe their influence on GDP per capita.

The question from which the study starts is the following:

Is the connection between innovation and performance a positive one?

The working hypotheses of the research are:

H_1 There is a link between investments in innovation and economic growth in Romania;

H_2 In Western European countries there is a strong link between innovation and performance;

H_3 Research and development spending influences economic growth.

4.1 Discussion of variables and data source

The variables used in the study are presented in **Table 1**.

Table no. 1: Variables

Variable name	Description	Unit	Source
Dependent variable			
GDP per capita	Gross domestic product per capita	Dolari current US$	WORLD BANK
Independent variables			
R&D	Research and development expenses	Millions of dollars	OECD
PAR	Patent applications for residents	Number of requests	WORLD BANK
PAT	Patent applications for non-residents	Number of requests	WORLD BANK
R 1000	Number of researchers per 1000 employees	Number of requests	OECD

Source: Table made by the author

4.2 Econometric specifications

For the analysis of the connection between the innovation variables and the economic growth variable, we used the Pearson correlation coefficient.

In the paper we used a multiple regression analysis, the econometric model being of the form:

$$y_i = b_0 + b_1 * x_1 + b_2 * x_2 + b_3 * x_3 + b_4 * x_4 + e$$

The analysis of the relationship between the innovation variables R&D, PAR, PAN, R 100 and GDP per capita was performed by the multifactorial linear regression model: where y_i represents the variable dependent on the model, $x_1, x_{2,} x_{3,}$ şi $x_{4,}$ are the independent variables, and ε we represent the error or the random variable from the econometric model. To analyze the link between innovation and performance variables, we chose to use the SPSS statistical program to perform the regression analysis.

To examine the association between the dependent and the independent variables, multiple linear regression is used.

For testing the hypotheses, the following econometric model was estimated:

GDP $= \boldsymbol{b_0} +$ $\boldsymbol{b_1}$****R&D*** $+$ $\boldsymbol{b_2}$****PAR*** $\boldsymbol{b_3}$****PAN+***$\boldsymbol{b_4}$****R 1000 + ε***

In the present study we used the statistical program SPSS, and by using it we calculated the value of the regression coefficients in the model for all countries included in the study. Determining the GIS value of each coefficient we could thus interpret whether or not there is statistical significance (sig. <0.05).

5. ANALYSES

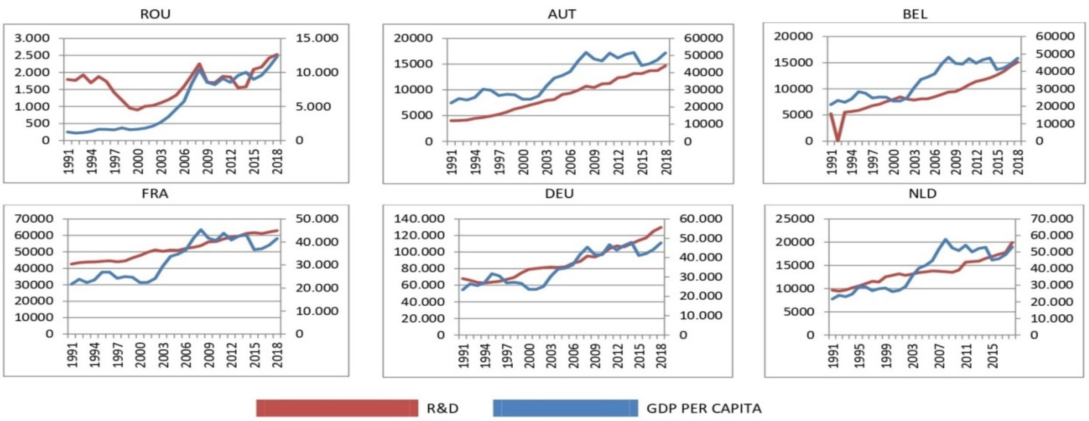

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Figure no. 1: Evolution of GDP per capita and R&D in Romania and in the five Western European countries

Research and development (R&D) expenditures register a decreasing trend from 1991 to 2000 and an ascending one starting with 2000 and until 2018 in Romania.

We can see that in Romania since 2000, R&D and GDP are evolving at a close pace, following the same trend.

At the level of Austria R&D, they have an increasing linear trend, as they do not have decreasing tendencies towards GDP in the analyzed horizon.

Belgium has a similar trend to Austria, but since 1993, GDP per capita has fluctuated slightly.

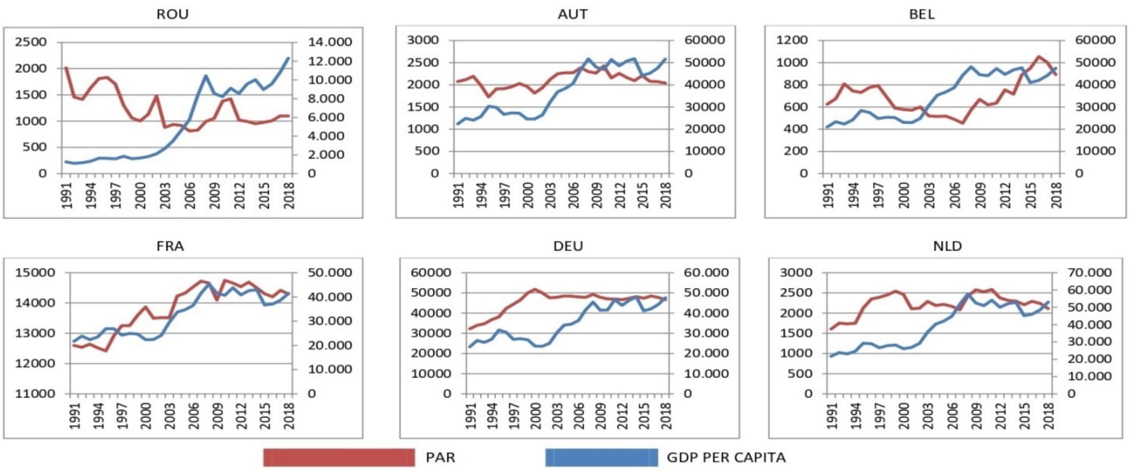
In France, R&D also has an increasing evolution, GDP being also in a continuous growth with small corrections.

At the level of Germany, we also observe an upward evolution of R&D as well as of GDP, with small decreases in its decrease.

The Netherlands reaches the highest value of GDP in 2008, thus following a correction until 2018.

We can observe the approximately linear and uninterrupted growth of research and development expenditures in the analyzed horizon, the conclusion being that investments in research produce added value that leads to performance.

Gross domestic product per capita has increased over the years, its trend being followed by research and development (R&D) expenditures of the countries included in the study.



Source: Data processed by the author in excel

Figure no. 2: Evolution of GDP per capita and PAR in Romania and in the five Western European countries

The evolution of RIP in Romania is declining compared to GDP.

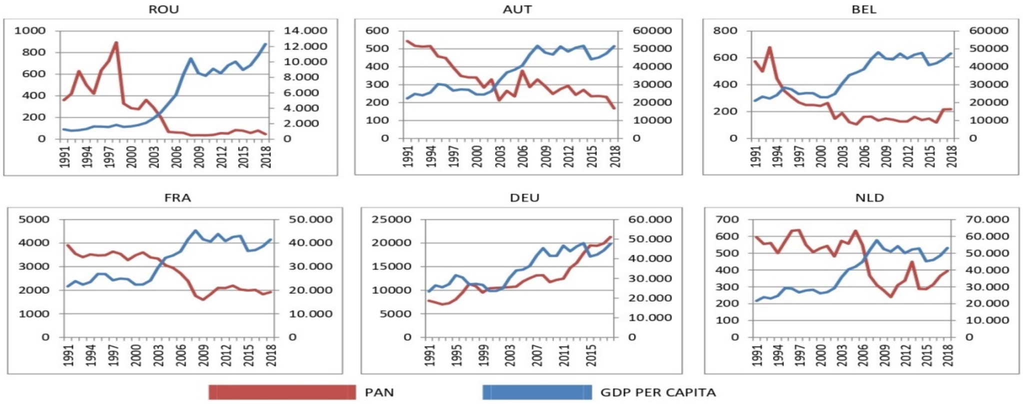
At the level of Austria, PAR remains approximately constant over the analyzed horizon, with GDP growing.

Belgium registers decreasing values of the PAR until 2008 followed by a continuous increase until 2018.

In France, the evolution of PAR and GDP is increasing, the PAR being directly proportional to GDP.

At the level of Germany, the PAN registers an upward trend until the year 2000, after which it remains constant throughout the analyzed horizon.

In the Netherlands, PAN fluctuates slightly, but it remains constant over the given time horizon.



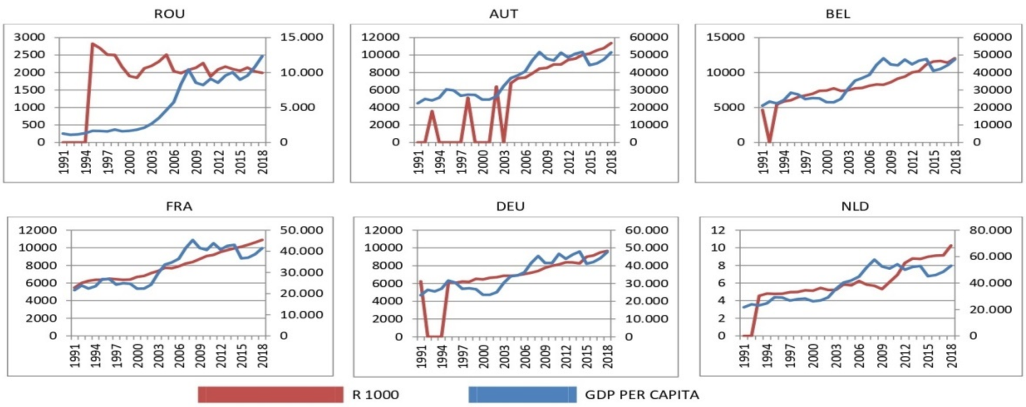
Source: Data processed by the author in excel

Figure no. 3: Evolution of GDP per capita and PAN in Romania and in the five Western European countries

Compared to GDP per capita, the number of non-resident patent applications (PAN) decreases in most of the analyzed countries, except in Germany, where the PAN is directly proportional to GDP per capita.

We can observe a general downward trend in the PAN, as well as a constant maintenance of the PAR in most countries, which reflects an encouragement from states for internal research.

The phenomenon of declining PAN can be explained by the fact that part of the researchers' efforts do not materialize in other patentable intellectual capital elements.



Source: Data processed by the author in excel

Figure no. 4: Evolution of GDP per capita and R 1000 in Romania and in the five Western European countries

In Romania, R1000 reached its peak in 1995, registering a decreasing trend in the following years. In Western European countries, the R1000 has a strong upward trend, growing at the same rate as GDP growth.

This indicator records zero values at the level of several years in the analyzed time horizon.

Table no. 2: Pearson correlation analysis

PEARSON CORELATION	ROMANIA	AUSTRIA	BELGIUM	FRANCE	GERMANY	NETHERLANDS	
GDP PER CAPITA							N
R&D	.647	.913	.778	.845	.856	.791	28
Sig.	.000	.000	.000	.000	.000	.000	28
PAR	-.527	.591	.211	.867	.408	.485	28
Sig.	.002	.000	.140	.000	.016	.004	28
PAN	-.795	-.689	-.688	-.940	.785	-.788	28
Sig.	.000	.000	.000	.000	.000	.000	28
R 1000	.299	.889	.758	.858	.643	.706	28
Sig.	.061	.000	.000	.000	.000	.000	28

Source: Data calculated using SPSS and processed by the author in excel

Correlation between R&D and GDP per capita

At the level of Romania we register a strong correlation of 0.647. Although the correlation is a positive one, it is weaker than in the rest of the analyzed countries, Romania being met according to the EIS (European Innovation Scoreboard) ranking among modest innovators.

According to the same ranking, among the strong innovators we find Belgium, with a correlation of 0.778, France with 0.845, Germany with 0.856 and Austria, which recorded the strongest correlation index of 0.913.

The Netherlands is one of the leaders in innovation and has a positive and strong correlation of 0.791.

It is thus found that the strongest correlation between R&D and GDP is found in Austria, which is among the strongest innovators.

According to table 2, in the case of Romania, a high level of correlation can be observed between R&D and GDP, thus validating the hypothesis $\mathbf{H_1}$.

Correlation between PAR and GDP per capita

This correlation, in Romania, is an inverse of -0.527, which shows that innovation could have a long-term effect on macroeconomic performance indicators in underdeveloped countries.

We find a strong correlation between PAR and GDP in the case of Austria of 0.591, the evolution of the two indicators being increasing.

A positive but weak correlation of only 0.211 is found in Belgium, the relationship between the two indicators being non-linear, the number of patent applications registered by residents fluctuates differently from the other variables.

At the level of France, the strongest correlation between the RIP and the GDP of 0.867 can be observed, the number of patent applications of the residents being increasing.

In Germany, the RIP remained constant over the period 2001-2018, while the number of non-resident researcher patent applications increased, so that the country's correlation index is 0.408 (sig = 0.016), with a positive but weak correlation.

The Netherlands shows slight fluctuations in RIP and GDP, finding a positive correlation, but slightly weaker than 0.485 (sig = 0.004).

Correlation between PAN and GDP per capita

Between PAN and GDP, in Romania, the correlation is an inverse of -0.795, which can be explained by the fact that innovation can have a long-term effect on economic growth, in the case of less developed countries.

Austria shows an inverse correlation of -0,689 between PAN and GDP, thus reflecting the tendency to quantify research results in another form.

In Belgium, the correlation is strong, but inverse of -0.688, the indicator being inversely proportional to economic growth. Here, too, there is a high tendency to quantify research results in forms other than patentable ones.

In France, between PAN and GDP, we find a strong but inverse correlation of -0,940, this shows that in France there is a strong tendency to decrease the number of patents from non-resident researchers in that country, in favor of increasing registered patents by resident researchers.

Germany recorded a correlation of 0.785 (sig = 0.000), while the correlation index between R 1000 and GDP is 0.643 (sig = 0.000), which indicates a strong relationship between innovation and macroeconomic performance in this country.

The phenomenon can be explained by the high level of development of countries with a high degree of innovation, so that if a country is more economically developed, innovation can be correlated with economic growth.

A significant but inverse correlation can be found in the Netherlands, where the correlation index is -0,788 (sig. = 0.000), the number of patent applications of non-residents being decreasing compared to GDP per capita.

Correlation between R1000 and GDP per capita

In Romania, this correlation is low, but positive of 0.299, but sig. = 0.061, which has no statistical significance (sig.> 0.05).

In the case of Romania, only one of the four variables has a high correlation, a possible explanation being the fact that innovation does not have strong or immediate effects in less developed countries.

A very high correlation is in the case of Austria of 0.889, so it can be explained how the number of researchers per 1000 employees correlates strongly with GDP.

Belgium has a strong correlation of 0.758, which is significant because sig = 0.000.

A strong and positive correlation, which confirms the idea that investments in innovation take effect in the year in which they are made, was registered in France with 0.858 and sig = 0.000.

At the level of Germany, a positive correlation of 0.643 (sig. = 0.000) can be observed, which indicates a strong relationship between innovation and macroeconomic performance in this country.

In the Netherlands, between R 1000 and GDP, there is a strong correlation of 0.706 (sig. = 0.000), indicating a strong increase in the number of researchers on the same trend as gross domestic product per capita.

In Western European countries there are more statistically significant correlations compared to Romania and the $\mathbf{H_2}$ hypothesis is thus confirmed.

Table no. 3: Regression results for Romania, Austria and Belgium

ROMÂNIA			AUSTRIA			BELGIUM		
Variables	Coefficient	P-VALUE	Variables	Coefficient	P-VALUE	Variables	Coefficient	P-VALUE
The constant	111,520	0,955	**The constant**	-19.805,337	0,202	**The constant**	32.072,661	0,001
R&D	4,876	0,000	**R&D**	2,793	0,001	**R&D**	4,829	0,044
PAR	-2,605	0,045	**PAR**	11,985	0,050	**PAR**	-1,891	0,859
PAN	-6,568	0,001	**PAN**	18,493	0,199	**PAN**	-26,129	0,080
R 1000	1,098	0,009	**R 1000**	0,241	0,623	**R 1000**	-4,004	0,194
R	**0,934**		**R**	**0,941**		**R**	**0,828**	
R2	**0,872**		**R2**	**0,885**		**R2**	**0,685**	
F-statistic (p-value)	**39,251**		**F-statistic (p-value)**	**44,138**		**F-statistic (p-value)**	**12,523**	
Significance F	**0,000**		**Significance F**	**0,000**		**Significance F**	**0,000**	

Source: Data calculated using SPSS and processed by the author in excel

As can be seen in Table 3, in Romania, research and development expenditures have a positive influence on macroeconomic performance, while also having statistical significance (p-value = 0.000).

The number of researchers per 1000 employees positively influences the GDP per capita, having a positive and statistically significant influence.

Increasing investment in innovation does not lead to an increase in patents.

We can explain this phenomenon in the light of the fact that not all research is quantified in something that is patented, intellectual capital having various forms that are expressed.

The number of patents, both in the case of residents and in the case of non-residents, has a negative influence, the latter being in a continuous decrease from one year to another.

Research and development expenditures, recorded by Austria, are a favorable factor of economic growth, as shown by the positive link (2,793), also having statistical significance (p-value = 0.001) among the variables analyzed.

GDP is positively influenced by PAR (11,985), the latter also having statistical significance (p-value = 0.05), PAN and R 1000 being statistically insignificant (p-value> 0.05).

In the case of Belgium, a positive influence of R&D on economic growth can be observed (4,829), while also having statistical significance (p-value = 0.044).

The coefficients of the other independent variables, respectively PAR, PAN and R 1000 have a negative influence on economic growth, as they have statistical significance (p-value> 0.05).

Table no. 4: Regression results for France, Germany and the Netherlands

FRANCE			GERMANY			NETHERLANDS		
Variables	Coefficient	P-VALUE	Variables	Coefficient	P-VALUE	Variables	Coefficient	P-VALUE
The constant	18.508,723	0,348	**The constant**	6.057,233	0,567	**The constant**	15.269,095	0,444
R&D	-0,738	0,149	**R&D**	0,466	0,004	**R&D**	2,328	0,064

FRANCE			GERMANY			NETHERLANDS		
Variables	Coefficient	P-VALUE	Variables	Coefficient	P-VALUE	Variables	Coefficient	P-VALUE
PAR	4,034	0,004	**PAR**	-0,163	0,526	**PAR**	6,268	0,259
PAN	-8,125	0,000	**PAN**	-0,529	0,467	**PAN**	-41,812	0,004
R 1000	2,450	0,261	**R 1000**	0,311	0,650	**R 1000**	-405,991	0,752
R	**0,959**		**R**	**0,862**		**R**	**0,873**	
R2	**0,919**		**R2**	**0,743**		**R2**	**0,762**	
F-statistic (p-value)	**65,342**		**F-statistic (p-value)**	**16,632**		**F-statistic (p-value)**	**18,386**	
Significance F	**0,000**		**Significance F**	**0,000**		**Significance F**	**0,000**	

Source: Data calculated using SPSS and processed by the author in excel

At the level of France, the GDP is negatively influenced by R&D, the coefficient of this variable being -0,738, (p-value = 0.149), proving that it is not statistically significant.

GDP is positively influenced by the RIP, its coefficient being 4,034, it is also statistically significant (p-value = 0.004).

PAN has static significance, it negatively influencing the macroeconomic performance, the coefficient being -8,125 (p value = 0.000).

GDP is positively influenced by R1000 but is not statistically significant (p-value = 0.261).

In Germany, GDP is positively influenced (0.466) by R&D, its influence having statistical significance (p-value = 0.004), the rest of the variables in the model being statistically insignificant.

In the Netherlands, R&D has a positive influence on GDP but is statistically insignificant (p-value = 0.064). A statistically significant, but negative, influence is found between PAN and GDP (-41,812).

Although it falls into the category of innovative leaders, the Netherlands does not have a positive or statistically significant influence from any of the innovation indicators, as evidenced by the fact that innovation does not always lead to economic growth, and there is a possibility that growth indicators will influence innovation.

In four of the six countries analyzed, namely Romania, Austria, Belgium and Germany, R&D has a positive and statistically significant influence on GDP per capita. Thus the hypothesis $\mathbf{H_3}$ is confirmed.

6. CONCLUSIONS

It is no coincidence that countries that devote more resources to research and development are high-income developed countries. The significant relationship between technological developments, innovation and research and development activities, as well as economic growth is observed in many studies in the literature.

In the present study, we observe strong correlations between R&D and GDP, both in Romania and in Western European countries.

The PAR had strong and positive influences on GDP only in the case of Austria and France, in Romania the correlation is significant, but inverse, and in Belgium, Germany and the Netherlands the correlation between PAR and economic growth is weak.

In Germany there is a strong and positive correlation between PAN and GDP, the other countries in the study having a strong correlation given negative.

At the level of Romania, R1000 registers a weak correlation, this being a strong and positive one in the countries from Western Europe.

It is observed that in the countries in the analyzed sample R&D and R 1000 have strong and significant correlations on economic growth, PAR has weak correlations in three of the six countries and PAN has an inverse correlation in five of them.

The non-correlation of the number of patent applications with GDP per capita is due to the tendency to quantify research in other forms than those through patents.

In Romania, Belgium, Austria and Germany, R&D has a positive influence on economic growth, with France and the Netherlands not having statistical significance.

The influence of RIP on GDP is positive and statistically significant, only in Austria and France.

The RIP has a negative influence on GDP in most countries, with a downward trend in all countries except Germany, where the trend is upward.

The influence of R1000 on GDP is positive, but statistically insignificant in most countries.

Research and development expenditures have the greatest influence on economic growth in most of the countries under study.

Although the information economy and high-tech sectors are very important for economic development, it is also clear that achieving economic growth will not be easy without investing in research and development.

Economic development leads to the financing of innovation that will produce added value over time and will implicitly lead to economic growth.

Therefore, it is not excluded that the influence between innovation and performance can be in both directions, the variables of innovation and performance mutually influencing each other.

The limits of research derive from the small volume of available data, which greatly limits the choice of variables that could be modeled and requires reconsideration of research ideas.

The design and implementation of an innovation reporting system at European level would help to know the contribution of innovation to a country's economic growth and would facilitate academic research.

As a perspective for further research, the aim is to analyze the effect of innovation on economic growth across several categories of countries, namely, underdeveloped countries, developing countries and developed countries.

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