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ORIGINAL SCIENTIFIC PAPER

Does the Increase in the Number of Registered Patents Affect Economic Growth? - Evidence from Romania and Bulgaria

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ABSTRACT
The goal of this paper is to determine whether the increase in the number of registered patents per million inhabitants, as a measure of market verification of the results of R&D activities, affects economic growth and the increase in the country's innovation index. The empirical research covered two countries - Romania and Bulgaria. Given that the main task of the research was to accurately measure the investigated phenomena and discover the connection between them, the analysis was based on a quantitative research design. The analysis used secondary data from the international databases of the World Bank and World Intellectual Property Organization, covering the period from 2008 to 2018. The results of the empirical research showed that no correlations were found, which means that in the cases of Romania and Bulgaria, there is no dependence between the increase in the number of registered patents per million inhabitants and the growth of the innovation index and GDP per capita.

Key words: *innovation, patents, innovation index, GDP per capita, development*

JEL Classification: O3

INTRODUCTION

Economic growth is a key element for improving living standards, reducing poverty and achieving common progress (World Bank, 2022). Countries that generate new technologies and encourage their adoption, as well as those that create innovations, grow faster than those countries that do not promote these activities (Domazet et al., 2021). The same authors state that patenting in certain industries is recognized as an important tool for protecting intellectual property and creating a sustainable competitive advantage. According to OECD (2004), patents have an important role in achieving innovation and economic performance. The changes that occurred in the last two decades regarding the patent policy of the OECD member countries encouraged the creation of patents to initiate investments in innovation and improve wedge. The OECD publication also points out that patents are intended to boost innovation in the private sector by enabling their inventors to profit from the invention. Moser (2013) argues that policies aimed at spreading ideas and modifying patent rights to stimulation could be an adequate way to encourage innovation. The important role of patents in stimulating innovation and economic growth was emphasized in 2012 by the then-president of the European Patent

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Organization (EPO), Benoît Battistelli, during his speech at the Bulgarian Inventors of the Year event (EPO, 2022). It is important to understand that for patents to have a positive impact on economic growth, it is necessary to apply them in practice (Atun et al., 2007).

Since the goal of every country is to achieve economic progress, numerous authors have examined the nature of the relationship between patents and economic growth. In this regard, some researchers have determined the existence of a positive relationship (Wurster, 2021; Maradana et al., 2017; Pelinescu, 2017; Nae & Grigore, 2014; Hasan & Tucci, 2010; Akçomak & Ter Weel, 2009; Sinha, 2008; Blind & Jungmittag, 2008; Crosby, 2000), while others identified the existence of a negative relationship between the mentioned variables (Silaghi & Medeşfălean, 2014; Domazet et al., 2022). On the other hand, Myszczyszyn (2020) and Blind et al. (2021) argue that there is no relationship between patents and economic growth in the long run.

Bearing in mind that Bulgaria and Romania are countries that acceded to the EU at the same time (2007) and that they are characterized by similar issues concerning patents – long-term process, high costs, as well a lack of incentives (Silaghi & Medeşfălean, 2014; World Bank, 2010), it is important to determine the nature of the relationship between patents and (a) economic growth and (b) innovation. In accordance with all the above, this paper aims to examine the relationship between the number of registered patents and economic growth and innovation in Bulgaria and Romania.

The paper is structured as follows: the results of relevant studies concerning the relationship between patents, economic growth and innovation are presented in the Literature review section. The methodology and results section describes the sample and applied statistical tests used to examine the nature of the relationship between patents, economic growth and innovation, and then presents the research results and their explanation. The last part of the paper deals with the conclusions of the conducted study.

LITERATURE REVIEW

Analyzing the nonlinear effect of R&D, patents and exports of high-tech products on economic growth in 35 OECD countries for the period 1992-2006, Ersin et al. (2022) have determined that there are significant marginal effects of economic growth rates, which are followed by threshold effects dominated by the participation of research and development in GDP. According to the research results of Pelinescu et al. (2019) there is a positive and significant impact of growth in R&D expenditure on GDP growth per capita. However, the authors point out that each country should adjust patent rights according to the country's development, as well as the development of the respective industry. In addition, they determined that stronger patent protection is not desirable in underdeveloped countries. Depending on the development of the economy, the contribution of patents to economic growth can differ (Eliasson et al., 2004). Pradhan et al. (2020) point to the role of intellectual property as one of the key drivers of economic growth. Bearing in mind that developed countries are characterized by a significant fund of technological knowledge and human capital (Alnuaimi et al., 2012), as well as appropriate institutional frameworks related to the protection of patents, that is, intellectual property rights (Candelin-Palmqvist et al., 2012), it can be concluded that developed countries may have better abilities to maximize utility from patents. Based on the analysis of data from 99 countries in the period 1996-2018, Rubilar-Torrealba et al. (2022) claim that the more developed a country is, the more patents it tends to have. The increase in the number of patents can contribute to the development of innovations that can have a positive impact on economic growth (Marjanović et al., 2019; Caseiro & Simões, 2019; Pradhan et al., 2019). The number of patents is considered to be an adequate indicator for evaluating the success of innovative activities (Dang & Motohashi, 2015). Patents can be used as a proxy for innovation Crosby (2000) or as an indicator of innovation (Blind et al., 2021). Patent data are more closely related to innovation than research and development data. In addition, patent data are more widely available since they cover a longer period and can be used in time series analysis Crosby (2000).

The research results, which in 1998-2016 included 43 countries (26 developed economies and 17 developing countries), showed that the number of new patents in the field of information and communication technologies (ICT patents) has a positive one-way impact on economic growth. It is important to note that this type of patent has a positive long-term impact. Also, the authors of the study identified a significant positive impact of patents on economic growth in developed countries. In contrast to developing countries, the impact of patents on economic growth is negative (Nguyen & Doytch, 2022). Analyzing 4 European countries and 12 sectors, Blind & Jungmittag (2008) found that patents contribute to economic growth. Likewise, the study points to the conclusion that patents are more important for growth in R&D-intensive industries. A positive impact of the number of patents on economic growth in the long term was identified in the study of Josheski & Koteski (2011), which covered the G7 countries in the period 1963–1993, while a negative impact was found in the short term. Sinha (2008) examined the relationship between the number of patents and economic growth in Japan and South Korea over the period 1963-2005. In the case of Japan, a two-way causal relationship was identified between the number of patents and real economic growth. In contrast to South Korea, there is a one-way relationship between real GDP growth to the growth in the number of patents. The results of the regression analysis showed that a 1% increase in key technological patents leads to an average increase in GDP per capita by 0.108% (Wurster, 2021). Maradana et al. (2017) determined the existence of a significant connection between patents and economic growth per capita in the long term based on data for 19 European countries in the period 1989–2014.

In Romania, Portugal, Belgium, Italy, Germany, Finland, Greece, the Netherlands and the UK, it was found that there is unidirectional causality from the number of resident patents to GDP growth. Additionally, the results point to the conclusion that there is unidirectional causality from economic growth per capita to the number of patents of residents in Hungary, Norway, the Czech Republic, Denmark and Ireland. In addition, a two-way causality was established between the number of resident patents and economic growth per capita. In the case of the number of non-resident patents in Romania, Belgium, the Czech Republic, France, the Netherlands, Spain and Sweden, there is unidirectional causality from the number of non-resident patents to economic growth per capita. Unidirectional causality from economic growth to the number of non-resident patents was identified in Norway, Greece, Finland and Germany. Bidirectional causality was found in Portugal, the UK, Denmark, Ireland and Hungary. The results of the research conducted by Crosby (2000) based on the data on the number of patent applications in Australia in the period 1901-1997 showed that the increase in patents leads to the economic growth of the country. Crosby (2000) established the existence of a positive relationship between patents and economic growth in the short term; however, Schmookler (2013) claims that this relationship should be negative in the short term, while it should be positive in the long term. Akçomak & Ter Weel (2009) claim that there is a positive impact of the number of patent applications per population on the growth of GDP per capita based on the analysis of data from European countries in the period 1990 - 2002. Hasan & Tucci (2010), based on data for 58 states in the period 1980 - 2003, revealed a positive influence of the ratio patents / R&D expenses on the growth of GDP per capita. The existence of a positive relationship between patents and economic growth was established in Romania (Nae & Grigore, 2014). Similar conclusions were obtained in a study conducted by (Pelinescu, 2017) based on data from UNESCO and Eurostat databases for the period 2000-2015.

A negative correlation between the number of patent applications and the GDP growth rate was identified in Malaysia, China and Indonesia based on the data from the period 2000-2009 (Saini & Jain, 2011). A study conducted by Silaghi & Medeşfălean (2014) based on the data for the period 1990-2010 in Romania shows that patents have a statistically significant negative impact on economic growth. In addition, it was determined that an increase in the number of patents by 1% leads to a decrease in GDP by 0.089%. The authors claim that technologies in Romania are most often imitated from abroad. It is also worth mentioning that companies that carry out R&D activities patent their products where they will sell them, which is usually outside the country. The biggest issues are considered to be the time required to obtain a patent, high costs and an underdeveloped market for trading the patented product. Iwaisako & Futagami (2013) explain the negative impact as a result of a high level of patent protection that significantly reduces the demand for capital, which consequently has a negative impact on output. Myszczyszyn (2020) claims that in the long run, there is no relationship between the number of patents and economic growth in Germany based on data from 1872–1913. Similar are the conclusions of Blind et al. (2021), who analyzed data related to the period 1981 - 2014 for 15 EU countries and found that there is no significant impact of patents on economic growth in the long term.

DATA ANALYSIS AND FINDINGS

Patents represent the product of innovative knowledge and facilitate the spread of technology, thereby stimulating economic growth. The main goal of the work was to determine whether the increase in the number of registered patents per million inhabitants affects economic growth, measured by GDP per capita, and the growth of innovation, measured by the innovation index of a country. The analysis was based on a quantitative research design (comparative approach). The empirical research covered two countries (Romania and Bulgaria) in the period from 2008 to 2018. The analysis used secondary data from internationally recognized databases on the phenomena that were the subject of research in this paper:

1. World bank and
2. World Intellectual Property Organization.

The secondary data used in the paper were based on several advantages that these data contain, and for that reason, were taken as relevant. The main reasons for choosing these databases are the ability to access identical data, their immediate availability, and the mutual comparability of data for Romania and Bulgaria. Keeping in mind the aspiration to avoid the possible existence of different measuring instruments for the same phenomena in the national statistics of the countries included in the analysis, the data of international organizations were chosen (Table 1) rather than the data of national statistics.

Table 1. Number of patents, innovation index and GDP per capita

Country	Romania				
Variable / Year	Total patents	Total population	Number of patents*	GII**	GDP ***
2008	-	20,537,875	-	2.44	6,730
2009	1,150	20,367,487	56.46	2.92	6,410
2010	1,501	20,246,871	74.13	3.22	6,190
2011	1,599	20,147,528	79.36	36.83	6,350
2012	1,244	20,058,035	62.02	37.80	6,510
2013	1,241	19,983,693	62.10	40.33	6,760
2014	1,252	19,908,979	62.88	38.08	7,020
2015	1,235	19,815,481	62.32	38.20	7,330
2016	1,255	19,702,332	63.70	37.90	7,720
2017	1,452	19,587,491	74.13	39.16	8,320
2018	1,501	19,473,936	77.08	37.59	8,700
Country	Bulgaria				
2008	-	7,492,561	-	2.12	5,140
2009	397	7,444,443	53.32	2.85	4,990
2010	391	7,395,599	52.87	3.26	5,050
2011	395	7,348,328	53.75	38.42	5,300

2012	371	7,305,888	50.78	40.70	5,350
2013	500	7,265,115	68.82	41.33	5,400
2014	467	7,223,938	64.65	40.74	5,530
2015	512	7,177,991	71.33	42.16	5,790
2016	427	7,127,822	59.91	41.42	6,050
2017	425	7,075,947	60.06	42.84	6,310
2018	459	7,024,216	65.34	42.65	6,550

*Notes: *number of patents per million inhabitants; **GII = global innovation index; ***GDP per capita*

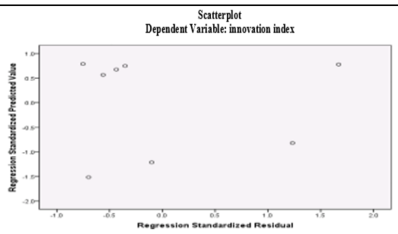
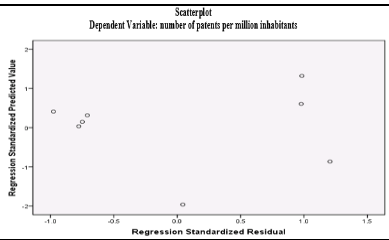
Source: WIPO (2019), Country profile – Romania, Bulgaria, available at: https://www.wipo.int/ipstats/en/statistics/country_profile/; World Bank (2019), Total population by country - Romania, Bulgaria, available at: https://data.worldbank.org/indicator/SP.POP.TOTL

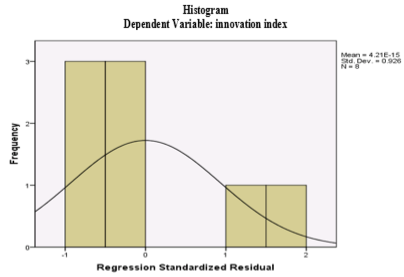
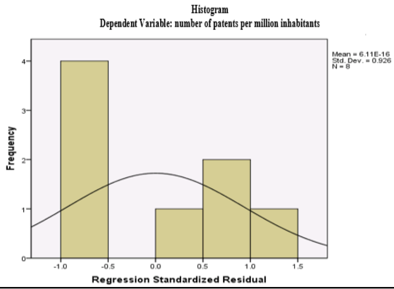
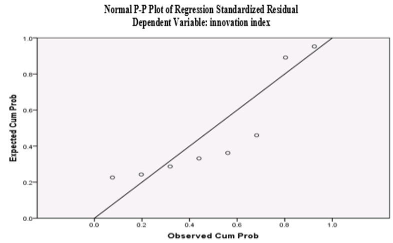
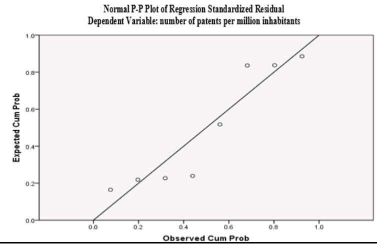
Since the secondary data available in international databases had the character of time series, appropriate econometric models for time series were used in the analysis. Statistical testing of correlations between the variables shown in Table 1 was performed through simple linear regression for each pair of independent and dependent variables individually. This was performed because the small sample size (n < 30) and the nature of the formulated hypothesis (only one independent and two dependent variables) did not allow the application of a more complex regression technique such as multiple regression or multivariate multiple regression, which require the existence of at least two independent variables and significantly a larger number of observations (Hair et al., 2014).

Given that no data were available on the total number of registered patents for Romania and Bulgaria for 2008, it was not possible to calculate the number of patents per capita. If you look at the data on the innovation index from Table 1, you can see that the data for the first three years (2008, 2009 and 2010) were presented using a different methodology compared to the other observation periods. For the results of the statistical analysis to be precise and clear, the research used data for the period from 2011 to 2018. Statistical testing of relationships between variables was performed through simple linear regression for each pair of independent and dependent variables individually for Romania and Bulgaria.

In the first case, in the example of Romania, the task was to determine whether all six assumptions (Ass.1 - Ass.6) were fulfilled for both observed variables (the dependent variable is the innovation index; the independent variable is the number of patents per million inhabitants). The results of the simple linear regression are presented in Table 2.

Table 2. Verification of fulfillment of assumptions - Case I (Romania)

Variable / assumption	**Number of patents per million inhabitants (n = 8)**	**Innovation index (n = 8)**
The nature of the variable	Metric	Metric
Distribution diagram		
Value of indicators of Durbin-Watson statistics	d = 2.558	d = 1.539

<table>
<tr><th>Variable / assumption</th><th>Number of patents per million inhabitants (n = 8)</th><th>Innovation index (n = 8)</th></tr>
<tr><td>Histogram</td><td>
</td><td>
</td></tr>
<tr><td>P-P normality diagram</td><td>
</td><td>
</td></tr>
</table>

Source: Authors' research

Ass. 1. The task was to determine whether the variables have a continuous nature. The analysis showed that both observed variables have a metric measurement and are therefore treated as metric variables measured on a ratio scale. The assumption is fulfilled.

Ass. 2. and **Ass. 3.** In the conducted analysis, it was not established that there is a linear relationship between the dependent and independent variables. Also, the absence of atypical points was not determined (distribution diagram, table 2). The assumptions are not met.

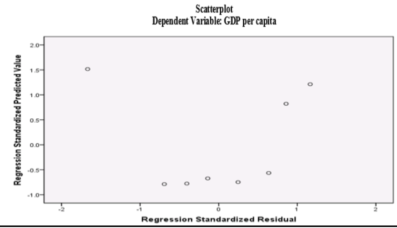
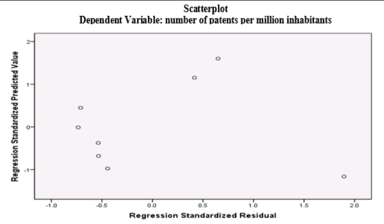
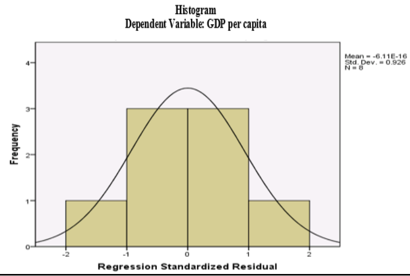
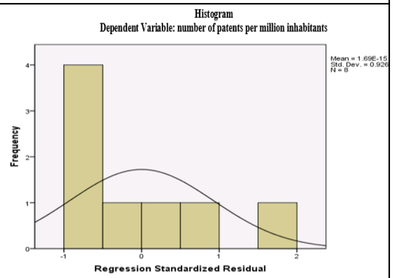
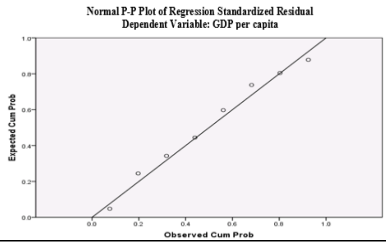
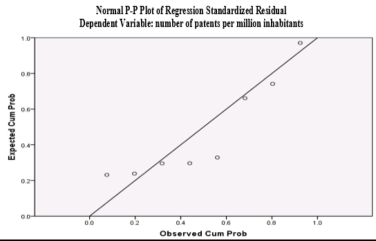
Ass. 4a. Based on the conducted Durbin Watson statistic and the obtained results shown in table 2, it was determined that there is no independence of observations when it comes to the number of patents per million inhabitants (d=2.558). The assumption is not met.

Ass. 4b. Based on the conducted Durbin Watson statistic and the obtained results shown in table 2, it was determined that observations are independent when it comes to the country's innovation index (d=1.539). The assumption is fulfilled.

Ass. 5. and **Ass. 6**. Based on the performed analysis and obtained results shown in table 2 (histograms and P-P diagrams of normality), it was determined that there is no absence of heteroskedasticity and normal distribution of residual errors. Assumptions are not made.

In the second case, in the example of Romania, the task was to determine whether all six assumptions (Ass.1 - Ass.6) were fulfilled for both observed variables (dependent variable = GDP per capita; independent variable = number of patents per million inhabitants). The results of the simple linear regression are presented in Table 3.

Table 3. Verification of fulfillment of assumptions - Case II (Romania)

<table>
<tr><th>Variable / assumption</th><th>Number of patents per million inhabitants (n = 8)</th><th>GDP per capita (n = 8)</th></tr>
<tr><td>The nature of the variable</td><td>Metric</td><td>Metric</td></tr>
<tr><td>Distribution diagram</td><td>
</td><td>
</td></tr>
<tr><td>Value of indicators of Durbin-Watson statistics</td><td>d = 0.258</td><td>d = 1.140</td></tr>
<tr><td>Histogram</td><td>
</td><td>
</td></tr>
<tr><td>P-P normality diagram</td><td>
</td><td>
</td></tr>
</table>

Source: Authors' research

Ass. 1. The task was to determine whether the variables have a continuous nature. The analysis showed that both observed variables have a metric measurement and are therefore treated as metric variables measured on a ratio scale. The assumption is fulfilled.

Ass. 2. and **Ass. 3**. In the conducted analysis, it was not established that there is a linear relationship between the dependent and independent variables. Also, the absence of atypical points was not determined (distribution diagram, table 3). Assumptions are not met.

Ass. 4. Based on the conducted Durbin Watson statistic, it was determined that (a) there is no independence of observations when it comes to the number of patents per million inhabitants (d=0.971), (b) there is no independence of observations when it comes to GDP per capita (d=1.052). The assumption is not met.

Ass. 5. and **Ass. 6**. Based on the performed analysis and the obtained results shown in table 3. (histograms and P-P diagrams of normality), it was determined that in the case of the independent variable (number of patents per million inhabitants) there is an absence of heteroscedasticity and normal distribution of residual errors. In contrast, in the case of the dependent variable (GDP per capita), this was not the case. The assumptions are partially fulfilled.

Given that the obtained results showed that these assumptions were not met or only partially met, the next task was to transform the data based on the logarithm (table 4).

Table 4. Results of linear regression

Model Summary[b]

Variables
The number of patents per million inhabitants and the country's innovation index

R	R Square	Adjusted R Square	SE of the Estimate
0.417[a]	0.174	0.036	0.01177

a. Predictors: (Constant), patent_transf
b. Dependent Variable: indeks_i_transf

Variables
The number of patents per million inhabitants and GDP per capita

R	R Square	Adjusted R Square	SE of the Estimate
0.329[a]	0.108	-0.041	0.05052

a. Predictors: (Constant), patent_transf
b. Dependent Variable: BDP_i_transf

ANOVA[b]

Variables
The number of patents per million inhabitants and the country's innovation index

	Sum of Squares	df	Mean Square	F	p
Regression	0.000	1	0.000	1.260	0.305[a]
Residual	0.001	6	0.000		
Total	0.001	7			

a. Predictors: (Constant), patent_transf
b. Dependent Variable: indeks_i_transf

Variables
The number of patents per million inhabitants and GDP per capita

	Sum of Squares	df	Mean Square	F	p
Regression	0.002	1	0.002	0.726	0.427[a]
Residual	0.015	6	0.003		
Total	0.017	7			

a. Predictors: (Constant), patent_transf
b. Dependent Variable: BDP_i_transf

Coefficients[a]

Variables
The number of patents per million inhabitants and the country's innovation index

	Unstandardized Coefficients		Standardized Coefficients	t	p
	B	Std. Error	Beta		
(Constant)	1.777	0.174		10.225	0.000
patent_transf	-0.107	0.095	-0.417	-1.122	0.305

a. Dependent Variable: indeks_i_transf

Variables
The number of patents per million inhabitants and GDP per capita

	Unstandardized Coefficients		Standardized Coefficients	t	p
	B	Std. Error	Beta		
(Constant)	3.228	0.746		4.326	0.005
patent_transf	0.347	0.408	0.329	0.852	0.427

a. Dependent Variable: BDP_i_transf

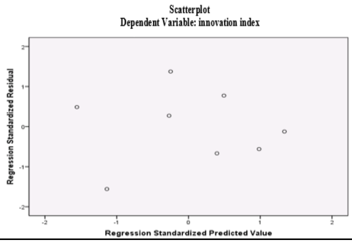
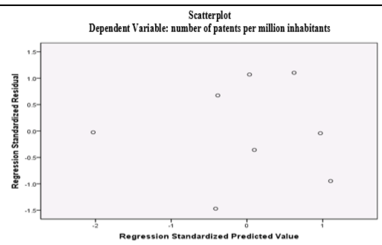
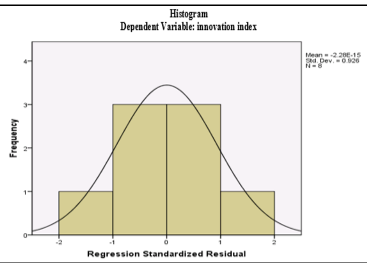
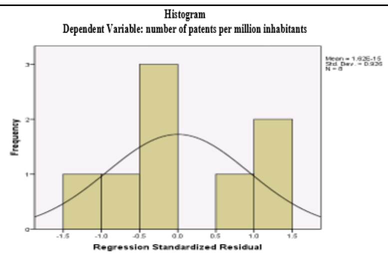
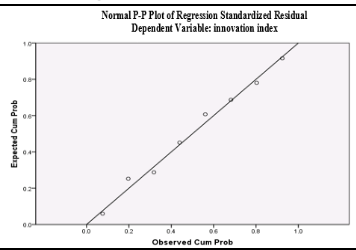
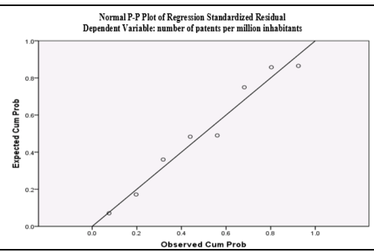
Source: Authors' research

In the simple linear regression model for the variables number of patents per million inhabitants and the country's innovation index, a correlation coefficient of R = 0.417 was determined, which, according to Cohen's criteria, can be considered a medium. Based on the obtained results, $R^2 = 0.174$ (coefficient of determination) and Adj.$R^2 = 0.036$ (corrected coefficient of determination), it is concluded that a total of 17.4% and 3.6% of changes in the dependent variable, the country's innovation index, can be explained by changes in the independent variable, the number of patents per million inhabitants. Based on the results of the ANOVA test ($F (1,6) = 1.260$ and $p = 0.305$), it can be concluded that the regression model at the $p < 0.050$ level was not statistically significant. That result provides additional information about the relationship between the independent and dependent variables included in the regression model and shows that the change in the number of patents per million inhabitants does not provide a statistically significant explanation for changes in the country's innovation index. The obtained results showed that the value of the ordinary regression coefficient is $B = 1.777$ ($SE\ B = 0.174$), while the value of the standardized regression coefficient is $\beta = -0.417$. Given that the coefficients of correlation and determination had a small value, with the absence of statistical significance of the regression model, it can be concluded that there is no statistically significant relationship between the number of patents per million inhabitants and the country's innovation index in the case of Romania.

In the simple linear regression model for the variables *number of patents per million inhabitants* and *GDP per capita*, a correlation coefficient of $R = 0.329$ was determined, which according to Cohen's criteria, can be considered as large (significant). Based on the obtained results $R^2 = 0.108$ (coefficient of determination) and Adj.$R^2 = -0.041$ (corrected coefficient of determination), the conclusion is that a total of 10.8% of changes in the dependent variable GDP per capita can be explained by changes in the independent variable number of patents per million inhabitants. However, this result should be taken with a grain of salt, while the entire explanatory power of the regression model should be assessed as insignificant. Based on the results of the ANOVA test ($F (1,6) = 0.726$, $p = 0.427$), it can be concluded that the regression model at the $p < 0.050$ level was not statistically significant. That result provides additional information about the relationship between the independent and dependent variables included in the regression model and shows that the change in the number of patents per million inhabitants does not provide a statistically significant explanation for changes in the GDP per capita. The obtained results showed that the value of the ordinary regression coefficient is $B = 3.228$ ($SE\ B = 0.746$), while the value of the standardized regression coefficient is $\beta = 0.329$. Given that the coefficients of correlation and determination had a small value, with the absence of statistical significance of the regression model, it can be concluded that there is no statistically significant relationship between the number of patents per million inhabitants and the GDP per capita in the case of Romania.

In the first case, using the example of Bulgaria, the task was to determine whether all six assumptions (Ass.1 - Ass.6) were fulfilled for both observed variables (dependent variable = innovation index; independent variable = number of patents per million inhabitants). The results of the simple linear regression are presented in Table 5.

Table 5. Verification of fulfillment of assumptions - Case I (Bulgaria)

Variable / assumption	**Number of patents per million inhabitants (n = 8)**	**Innovation index (n = 8)**
The nature of the variable	Metric	Metric
Distribution diagram		
Value of indicators of Durbin-Watson statistics	d = 1.220	d = 2.029
Histogram		
P-P normality diagram		

Source: Authors' research

Ass. 1. The task was to determine whether the variables have a continuous nature. The analysis showed that both observed variables have a metric measurement and are therefore treated as metric variables measured on a ratio scale. The assumption is fulfilled.

Ass. 2. and Ass. 3. In the conducted analysis, it was not established that there is a linear relationship between the dependent and independent variables. Also, the absence of atypical points was not determined (distribution diagram, table 5). The assumptions are not met.

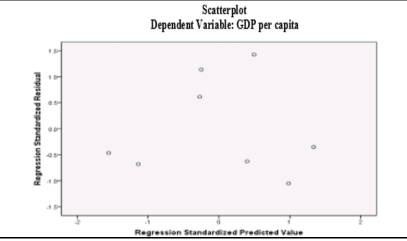
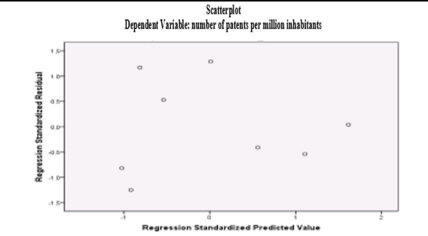
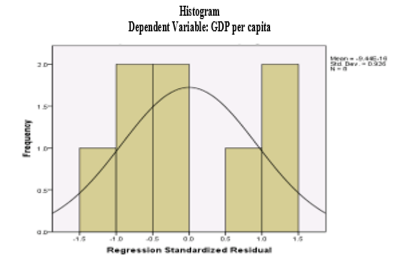
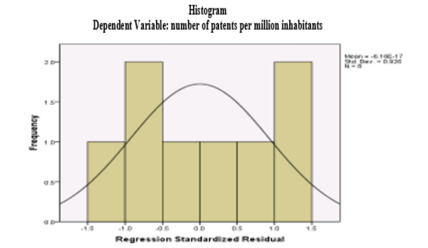
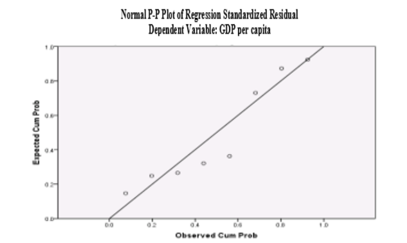
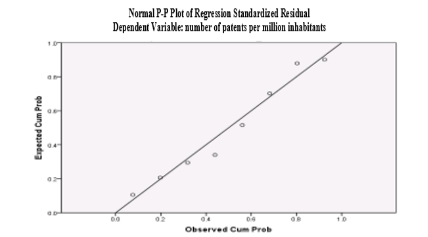
Ass. 4a. Based on the conducted Durbin Watson statistic and the obtained results shown in table 5, it was determined that there is no independence of observations when it comes to the number of patents per million inhabitants (d=1.220). The assumption is not met.

Ass. 4b. Based on the conducted Durbin Watson statistic and the obtained results shown in table 5, it was determined that observations are independent when it comes to the country's innovation index (d=2.029). The assumption is fulfilled.

Ass. 5. and Ass. 6. The results shown in table 5 (histograms and P-P diagrams of normality) were intended to show the absence of heteroskedasticity and the normal distribution of residual errors in the dependent and independent variables. The assumptions are partially fulfilled.

In another case, using the example of Bulgaria, the task was to determine whether all six assumptions (Ass.1 - Ass.6) were fulfilled for both observed variables (dependent variable = GDP per capita; independent variable = number of patents per million inhabitants). The results of the simple linear regression are presented in Table 6.

Table 6. Verification of fulfillment of assumptions - Case II (Bulgaria)

Variable / assumption	Number of patents per million inhabitants (n = 8)	GDP per capita (n = 8)
The nature of the variable	Metric	Metric
Distribution diagram		
Value of indicators of Durbin-Watson statistics	d = 0.322	d = 1.711
Histogram		
P-P normality diagram		

Source: Authors' research

Ass. 1. The task was to determine whether the variables have a continuous nature. The analysis showed that both observed variables have a metric measurement and are therefore treated as metric variables measured on a ratio scale. The assumption is fulfilled.

Ass. 2. and **Ass. 3**. In the conducted analysis, it was not established that there is a linear relationship between the dependent and independent variables. Also, the absence of atypical points was not determined (distribution diagram, table 6). Assumptions are not met.

Ass. 4a. Based on the conducted Durbin Watson statistic and the obtained results shown in table 6, it was determined that there is no independence of observations when it comes to the number of patents per million inhabitants (d=0.322). The assumption is not met.

Ass. 4a. Based on the conducted Durbin Watson statistic and the obtained results shown in table 6, it was determined that observations are independent when it comes to GDP per capita (d=1.711). The assumption is fulfilled.

Ass. 5. and **Ass. 6.** The results shown in table 6 (histograms and P-P diagrams of normality) were intended to show the absence of heteroscedasticity and the normal distribution of residual errors in the dependent and independent variables. The assumptions are partially fulfilled.

Given that the obtained results showed that these assumptions were not met or only partially met, the next task was to transform the data based on the logarithm (table 7).

Table 7. Results of linear regression

Model Summary[b]			
Variables The number of patents per million inhabitants and the country's innovation index			
R	**R Square**	**Adjusted R Square**	**SE of the Estimate**
0.560[a]	0.313	0.199	0.01349
a. Predictors: (Constant), patent_transf b. Dependent Variable: indeks_i_transf			
Variables The number of patents per million inhabitants and GDP per capita			
R	**R Square**	**Adjusted R Square**	**SE of the Estimate**
0.319[a]	0.102	-0.048	0.03583
a. Predictors: (Constant), patent_transf b. Dependent Variable: BDP_i_transf			

ANOVA[b]					
Variables The number of patents per million inhabitants and the country's innovation index					
	Sum of Squares	df	Mean Square	F	p
Regression	0.000	1	0.000	2.739	0.149[a]
Residual	0.001	6	0.000		
Total	0.002	7			
a. Predictors: (Constant), patent_transf b. Dependent Variable: indeks_i_transf					
Variables The number of patents per million inhabitants and GDP per capita					
	Sum of Squares	df	Mean Square	F	p
Regression	0.001	1	0.001	0.680	0.441[a]
Residual	0.008	6	0.001		
Total	0.009	7			
a. Predictors: (Constant), patent_transf b. Dependent Variable: BDP_i_transf					

Coefficients[a]					
Variables The number of patents per million inhabitants and the country's innovation index					
	Unstandardized Coefficients		Standardized Coefficients	t	p
	B	Std. Error	Beta		
(Constant)	1.320	0.179		7.395	0.000
patent_transf	0.165	0.100	0.560	1.655	0.149
a. Dependent Variable: indeks_i_transf					
Variables The number of patents per million inhabitants and GDP per capita					
	Unstandardized Coefficients		Standardized Coefficients	t	p
	B	Std. Error	Beta		
(Constant)	3.370	0.474		7.106	0.000
patent_transf	0.219	0.265	0.319	0.825	0.441
a. Dependent Variable: BDP_i_transf					

Source: Authors' research

In the simple linear regression model for the variables number of patents per million inhabitants and the country's innovation index, a correlation coefficient of R = 0.560 was determined, which according to Cohen's criteria, can be considered large (significant). Based on the obtained results $R^2 = 0.313$ (coefficient of determination) and Adj.$R^2 = 0.199$ (corrected coefficient of determination), it is concluded that a total of 31.3% and 19.9% of changes in the dependent variable, the country's innovation index, can be explained by changes in the independent variable, the number of patents per million inhabitants. Based on the results of the ANOVA test ($F(1,6) = 2.739$ and $p = 0.149$), it can be concluded that the regression model at the $p < 0.050$ level was not statistically significant. That result provides additional information about the relationship between the independent and dependent variables included in the regression model and shows that the change in the number of patents per million inhabitants does not provide a statistically significant explanation for the changes in the country's innovation index. The obtained results showed that the value of the ordinary regression coefficient is $B = 1.320$ ($SE\ B = 0.179$), while the value of the standardized regression coefficient is $\beta = 0.560$. Given that the coefficients of correlation and determination had a small value, with the absence of statistical significance of the regression model, it can be concluded that there is no statistically significant relationship between the number of patents per million inhabitants and the country's innovation index in the case of Bulgaria.

In the simple linear regression model for the variables *number of patents per million inhabitants* and *GDP per capita*, a correlation coefficient of $R = 0.319$ was determined. According to Cohen's criteria, it can be considered a medium. Based on the obtained results $R^2 = 0.102$ (coefficient of determination) and Adj.$R^2 = -0.048$ (corrected coefficient of determination), the conclusion is that a total of 10.2% of changes in the dependent variable GDP per capita can be explained by changes in the independent variable number of patents per million inhabitants. However, this result should be taken with a grain of salt, while the entire explanatory power of the regression model should be assessed as insignificant. Based on the results of the ANOVA test ($F(1,6) = 0.680$, $p = 0.441$), it can be concluded that the regression model at the $p < 0.050$ level was not statistically significant. That result provides additional information about the relationship between the independent and dependent variables included in the regression model and shows that the change in the number of patents per million inhabitants does not provide a statistically significant explanation for changes in the GDP per capita. The obtained results showed that the value of the ordinary regression coefficient is $B = 3.370$ ($SE\ B = 0.474$), while the value of the standardized regression coefficient is $\beta = 0.319$. Given that the coefficients of correlation and determination had a small value, with the absence of statistical significance of the regression model, it can be concluded that there is no statistically significant relationship between the number of patents per million inhabitants and the GDP per capita in the case of Bulgaria.

CONCLUSION

The national innovation system of Romania includes numerous institutions, organizations and agencies that have a highly developed organizational structure. However, the developed organizational structure in the case of the national innovation system of Romania does not imply its efficiency because the system is excessively fragmented and needs to provide equal access to all actors in terms of financial support. Financial investments in the field of research, development and innovation in Romania in the analyzed period (2008-2018) are very low, the results of the policy in this area are modest, the demand for innovation is low while the supply of human resources is inadequate. In 2014, a new Law on Innovations was adopted with the task of interpreting private property rights and improving the development of patents, which was supposed to have a direct impact on the economy. Nevertheless, there was still a low interest of companies in activities in the field of research, development and innovation, and the majority of companies justified their attitude with large allocations, the riskiness of the venture and the uncertainty of the results. A small number of innovations derive from the structure of the Romanian economy itself, in which low and medium technologies prevail.

On the other hand, during the analyzed period, Bulgaria's innovation system, although institutionally developed, suffered from two pressing challenges - inefficiency and the absence of significant financial resources that would ensure its development. In addition, the main problems faced by Bulgaria in the field of research, development and innovation are their small application in the business sphere, weak demand for innovations, and poor cooperation between the academic community and the economy. However, despite all the developments that have taken place in the previous 10 years or so, Bulgaria's innovation system is still facing major challenges, among which are the basic ones: how to ensure the continuity of a satisfactory intensity of investment in research and development, how to improve cooperation with the business sector; and how to create a climate and framework for the introduction of public-private partnership in the research and development system.

Of all the forms of intellectual property and technological innovation, patents are most often associated with them since they protect the essence of technological innovation. To create innovations to introduce new and improved products or services to the market, or to introduce new and improved production processes, companies must invest in research and development. Therefore, the conducted research aimed to determine whether the increase in the number of patents per million inhabitants affects economic growth and the increase in the innovation index of Romania and Bulgaria. Based on the obtained coefficients of correlation and determination and the absence of statistical significance of the regression model, the obtained results of the empirical research showed that in the case of Romania and Bulgaria, the following applies:

(a) there is no statistically significant correlation between the number of patents per million inhabitants and the innovation index

(b) there is no statistically significant correlation between the number of patents per million inhabitants and GDP per capita.

If the national innovation systems of Romania and Bulgaria were to be compared, it could be concluded that there is an evident lack of cooperation between the business sector and the academic community. In addition, innovation in the economy is at a very low level. This is reflected in the entire system, which is inefficient and underfunded. All this supports the fact that the results obtained through this research are not a big surprise. In the analyzed countries, there are still many open dilemmas regarding cooperation between science and business. Thereupon, there is little demand for innovation, but also an open question of the success of applying for patents in the business sector. Based on all of the above, it is highly debatable whether Romania and Bulgaria would have more significant results if:

- there was an increase in the number of patents per capita,
- they invested more funds in the area of research and development, and
- they hired a significantly larger number of better-quality researchers.

The results of the conducted research, to a certain extent, can be of importance to decision-makers in Romania and Bulgaria through certain recommendations, which refer to the efficiency of national innovation systems and the level of demand for innovation within each national economy. Therefore, it is very important that policymakers in the field of innovation adequately present the impact that innovation has on the country's economy. An increase in the number of patents per million inhabitants does not guarantee that in these countries, there will be an increase in the innovativeness of the economy and an increase in well-being. For this to happen, it will be necessary for patents to have their application and for all actors in that process to understand that only the application of patents can enable significantly better results in business.

The conducted research also has several limitations. The first drawback is the relatively small sample, considering that the analysis was performed only for two countries - Romania and Bulgaria. For subsequent research, it is proposed to increase the sample to four or more countries, with the recommendation that they are countries of the European Union or countries of one region. The small number of indicators analyzed is another limitation of this research. Given that the focus of this paper was on determining the impact of the number of patents on innovation and economic growth of the country, the recommendation for future research is to expand the list of indicators to be analyzed (e.g., production growth, employment growth, competitiveness). In this research, the analysis was performed for the period 2008-2018, which represents the third limitation of this work. In some future research, it is recommended to use data from as long a time series as possible (e.g. 30 years).

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