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The influence of the number of patents on the economic growth of the country – evidence from Serbia and Hungary

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Abstract

Background: One of the indicators of a country's innovation is the total number of registered patents. This paper analyzes the number of registered patents and the impact they can have on the country's economic growth and innovation. .

Purpose: The paper aims to determine whether there is a positive impact of market verification of the results of research and development activities, measured by the number of patents per million inhabitants, on economic growth and the growth of innovation in the country.

Study design/methodology/approach: Quantitative research design was applied in the analysis since the task was to investigate the influence of the number of patents on the economic growth of the country. The empirical research covered two countries - Serbia and Hungary. It used secondary data from the international databases of the World Bank and World Intellectual Property Organization, covering the period from 2008 to 2018.

Finding/conclusions: The results of the empirical research showed that the increase in the number of patents per million inhabitants contributes only to the innovation index's growth in Hungary. On the other hand, in the case of Serbia, there is no statistically significant relationship between the number of patents per million inhabitants and the country's innovation index, or the number of patents per million inhabitants and GDP per capita.

Limitations/future research: The limitations are: the small number of analyzed countries and the number of indicators analyzed. Therefore, in the framework of future research, it would be desirable to expand the analysis to more countries and establish the impact of patents on more indicators of innovation.

Keywords

Patents, innovation, GDP per capita, economic growth

Introduction

Scientific and technological progress has created new waves of innovation, especially in information and communication technologies. Thus, innovation processes have become less focused on individual companies and more dependent on the interaction between global networks of actors in the public and private sectors. The technological-innovation system implies networks, that is, a system of networks, of connected actors whose functions relate to a certain technological field and which include the creation, expansion and use of technology. The list of actors of a certain technological innovation system can be determined according to the databases of economic associations on companies classified according to different industrial branches, by analyzing the number of patents, which can indicate the scope and direction of technological activities in different organizations, by bibliometric analysis, which will enable the compilation of a list of the most active organizations in the field of technology development according to published works, or based on interviews and conversations with experts in the field of technology and industrial development.

Economic growth is attributed to the increase in national output resulting from technological innovation. For many years, innovation has been accepted as a basic factor of economic growth (Lee et al., 2010). As competition between countries increases and global growth slows, the need to prioritize innovation and research and development has never been stronger. The link between innovation and economic growth is undeniable but also complex. Public and private sector investments create jobs, develop industry, encourage innovation and make the country's economy more competitive in many different areas. Innovation plays a central role in ensuring economic and social prosperity, boosts productivity and leads to market growth. There are a number of different ways of measuring innovation, such as research and development spending, the number of patents in one year, the number of researchers per thousand full-time employees, as well as the widespread effect of technology spillovers between firms, industries and countries. The increased use of patents to protect inventions by companies and research organizations is closely related to the development of innovation processes and economies.

1. Literature review

Innovations are regarded as the engine of growth and long-term economic development of a country (Hai et al., 2022). According to Alheet & Hamdan (2022), "innovation is often seen as a driving force for a country's sustainable and long-term economic growth". Although innovations are considered an undeniable engine of growth, they can also have harmful consequences for society and the environment (Biggi & Giuliani, 2021). According to Lomachynska & Podgorna (2018), the success of a country's economy is determined by its innovative development. Research and development is a key contributor to organizations' pursuit of innovation (Scoresby et al., 2022). Research and development and innovation activities, which lead to technological progress, are considered important factors that contribute to stable and continuous economic growth" (Abibo et al., 2022, p. 4). The effect of institutions on innovation is particularly pronounced for high-tech innovations, which suggests that innovations could be a key channel through which institutions stimulate economic growth (Donges et al., 2022; Domazet et al., 2021; Kicová, 2019).

Innovation is imperative for the economic viability and sustainability of organizations (Nanyangwe et al., 2021). Governments and organizations that invest more in R&D create innovations that lead to an increase in the competitiveness of their products and services, GDP growth and a higher level of population well-being (Androniceanu et al., 2020). Technology transfer and productivity consecutively fully mediate the relationship between innovation and competitiveness (Rambe & Khaola, 2022). Also, competition exerts a feedback effect on market structure via the process of innovation (Sandrini, 2022). One of the most effective methods for raising the competitiveness of the economy and stable and continuous economic growth are research and development activities (Kim, 2011). The fact is that numerous innovations have improved quality and lowered prices for many input factors, which contribute to the competitiveness of the industry (Lebel et al., 2021). However, financial crises generally have a negative influence on companies' willingness to innovate (Disoska, et al., 2020). Increasing competitiveness brings economic changes as a result of the application of more modern technologies and new methods of production, with the development of completely new skills (Domazet et al., 2018). The innovation systems approach stresses the diversity of types, forms, and sources of knowledge that are required for successful innovation processes (Daimer et al., 2021). Sustainability-driven innovation takes many forms: from developing new or improved products or services to creating new processes and business models (Strielkowski et al., 2022). The link between innovation and economic growth must have an adequate institutional framework, as well as expert human capital, and all for the purpose of commercializing a new product. This is precisely the way to promote economic growth through innovative activities (Law et al., 2020). Developing economies, which recognize the importance of innovation, are implementing activities to improve their innovation capabilities (Sharma et al., 2018).

According to Yesilay et al. (2015, p. 1), "there is a significant relationship between R&D activities and R&D experiences and patents". Research on innovation has grown in recent decades, and most papers on this topic use patents as variables to measure innovation (Chang et al., 2018; Frietsch et al., 2014; Falk & Train, 2017; Sampat & Williams, 2019). R&D investment is the most significant factor affecting patenting (Li et al., 2020). Patents have a significant positive impact on trade in services, science and technology (Marjanović et al., 2019). The total number of patents filed in a country is often used as an indicator for innovation (O'Neale & Hendy, 2012). More patents lead to more innovation and vice versa, a patent can be an economic policy instrument to encourage investment in R&D (Tanane, 2020). The main reason why states allow patent protection is to encourage innovation. However, the magnitude of R&D incentives and patent protection depends on how effective patents are as a mechanism for profit appropriation (Czarnitzki & Toole, 2011). Measuring patent similarity, as one of the basic elements for patent analysis, can reveal and assess whether an invention meets the criteria of novelty and innovation (An et al., 2021). However, it is very difficult to estimate the value of a patent before its commercialization in the market (Hsieh, 2013). Stronger protection of patent rights is thought to encourage innovation by ensuring a return on investment in R&D (Maskus et al, 2019).

2. Methodology and results

Innovations are an important channel through which economic institutions contribute to a better effect of economic growth and increased production in the long term. Intellectual property rights, such as patents, aim to address the problem of underinvestment in research and development, allowing inventors a return on invested capital. The main goal of the paper was to verify the existence of a positive impact of market verification of the results of R&D activities, measured by the number of patents per million inhabitants, on:

- growth of the country's innovation index;
- country's economic growth, measured by GDP per capita.

The paper uses a quantitative research design, which was chosen because it investigates the relationships between variables that are measured on an interval or ratio scale. The features of the quantitative research design was to accurately measure the investigated phenomena and discover the connections between them. A comparative approach was chosen in order to examine the researched phenomena and their relationships in as much detail as possible within the framework of a quantitative research design. The analysis included two countries (Serbia and Hungary), while the time period was 2008 - 2018. The following international databases were chosen as sources of secondary data:

1. World Intellectual Property Organization
2. World Bank.

By its very nature, the collected secondary data had the character of time series, so appropriate econometric models for time series were used for the analysis.

Table 1. Data on the number of patents, innovation index and GDP per capita for Serbia and Hungary

Country	**Serbia**				
Variables / year	Total number of patents	Total number of inhabitants	Number of patents *	GII**	GDP ***
2008	-	7,350,222	-	-	4,380
2009	353	7,320,807	48.21	2.57	4,280
2010	391	7,291,436	53.62	2.68	4,330
2011	243	7,234,099	33.59	36.31	4,450
2012	234	7,199,077	32.50	40.00	4,400
2013	332	7,164,132	46.34	37.87	4,590
2014	289	7,130,576	40.53	35.89	4,540
2015	248	7,095,383	34.95	36.47	4,640
2016	279	7,058,322	39.53	33.75	4,820
2017	296	7,020,858	42.16	35.34	4,950
2018	308	6,982,084	44.11	35.46	5,190
Country	**Hungary**				
2008	-	10,038,188	-	2.88	10,500
2009	1,853	10,022,650	184.88	3.34	9,810
2010	1,634	10,000,023	163.40	3.54	9,900
2011	1,714	9,971,727	171.88	48.12	10,110
2012	1,655	9,920,362	166.83	46.50	10,010
2013	1,560	9,893,082	157.68	46.93	10,230
2014	1,434	9,866,468	145.34	44.61	10,690
2015	1,496	9,843,028	151.98	43.00	11,130
2016	1,538	9,814,023	156.71	44.71	11,410
2017	1,263	9,787,966	129.03	41.74	11,930
2018	1,340	9,768,785	137.17	44.94	12,560

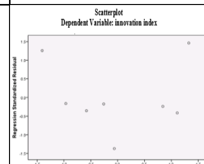
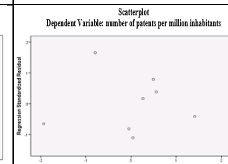
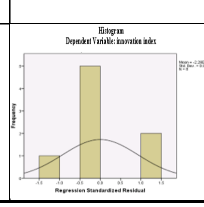
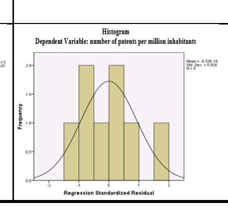
Notes: * calculated number of patents per million inhabitants; **GII = global innovation index; *** the data is presented as GDP per capita

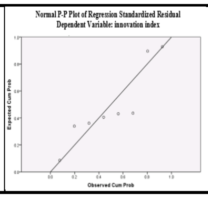
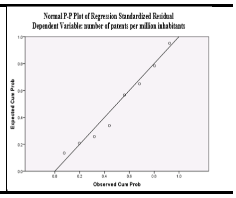
Source: The World Intellectual Property Organization (2019); World Bank (2019)

As shown in Table 1, data for the year 2008 on the total number of applied patents for the analyzed countries was unavailable. Consequently, the number of patents per capita for a given year could not be calculated. In addition, data on the innovation index of Serbia and Hungary for 2008, 2009 and 2010 were presented using a different methodology compared to the years that followed. Bearing in mind the above, and for the sake of the accuracy of the results of the statistical analysis, only the period from 2011 to 2018 was included in the analysis itself. Statistical testing of relationships between variables was performed using simple linear regression for each pair of independent and dependent variables individually.

In the first case, in the example of Serbia, the task was to determine whether all six assumptions (Ass.1 - Ass.6) were fulfilled for both observed variables (the dependent variable = innovation index; the independent variable = 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 (Serbia)

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 = 1.325	d = 1.606
Histogram		

P-P normality diagram		

Source: the 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.

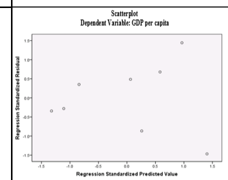
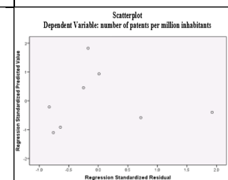
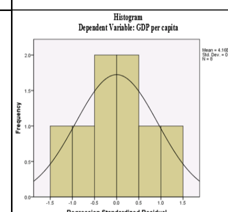
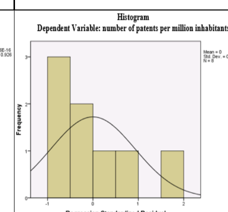
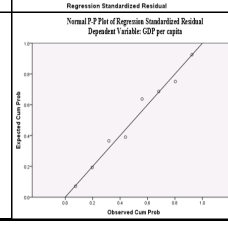
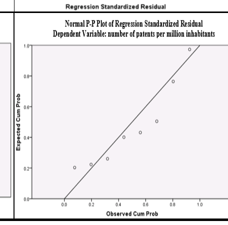
Ass. 4a. Based on the conducted Durbin Watson statistic and the obtained results shown in table 2, it was determined that there is no independence of observations when it comes to the number of patents per million inhabitants (d=1,325). The assumption is not met.

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=1.606). 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 Serbia, 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 (Serbia)

Variable / assumption	Number of patents per million inhabitants (n = 8)	BDP per capita (n = 8)
The nature of the variable	Metric	Metric
Distribution diagram		
Value of indicators of Durbin-Watson statistics	d = 0.625	d = 1.922
Histogram		
P-P normality diagram		

Source: the 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. 4a. Based on the conducted Durbin Watson statistic and the obtained results shown in table 3, it was determined that there is no independence of observations when it comes to the number of patents per million inhabitants (d=0,625). The assumption is not met.

Ass. 4b. Based on the conducted Durbin Watson statistic and the obtained results shown in table 3, it was determined that observations are independent when it comes to the country's innovation index (d=1.922). 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.

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
0.373[a]	0.139	-0.004	0.02202

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

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

R	R Square	Adjusted R Square	SE of the Estimate
0.631[a]	0.398	0.298	0.02058

a. Predictors: (Constant), patent_transf
b. Dependent Variable: BDP_and_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	0.971	0.363[a]
Residual	0.003	6	0.000		
Total	0.003	7			

a. Predictors: (Constant), patent_transf
b. Dependent Variable: index_and_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	3.973	0.093[a]
Residual	0.003	6	0.000		
Total	0.004	7			

a. Predictors: (Constant), patent_transf
b. Dependent Variable: BDP_and_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)	1.790	0.233	-0.373	7.689	0.000
patent_transf	-0.144	0.146		-0.985	0.363

a. Dependent Variable: index_and_transf

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

	Unstandardized Coefficients		Standardized Coefficients	t	p
	B	Std. Error	Beta		
(Constant)	3.238	0.217	0.631	14.888	0.000
patent_transf	0.272	0.137		1.993	0.093

a. Dependent Variable: BDP_and_transf

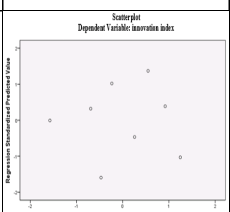
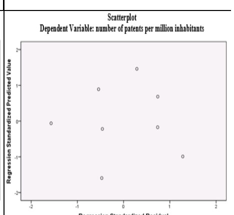
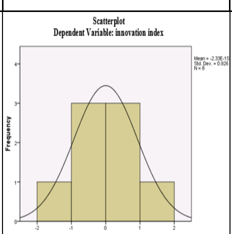
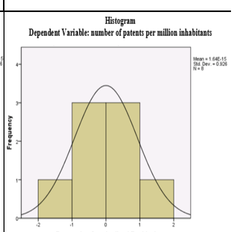
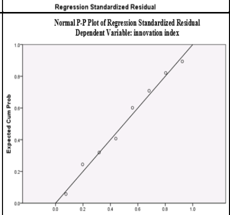
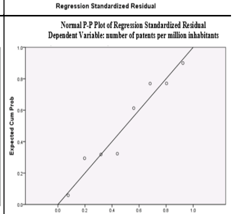
Source: the authors' research

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 = 0.373 was determined, which can be considered a medium according to Cohen's criteria. Based on the obtained results $R^2 = 0.137$ (coefficient of determination) and Adj.$R^2 = -0.004$ (corrected coefficient of determination), the conclusion is that a total of 13.7% of changes in the dependent country's innovation index can be explained by changes in the independent variable number of patents per million inhabitants (Domazet et al., 2022). Based on the results of the ANOVA test F (1,6) = 0.971, p = 0.363, it can be concluded that the regression model at the $p < 0.050$ level was not statistically significant. According to Domazet et al. (2022, 196-197), "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 = 1.790 (SE B = 0.233), while the value of the standardized regression coefficient is $\beta = -0.373$ (Domazet et al., 2022). 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 country's innovation index in the case of Serbia.

In the simple linear regression model for the variables number of patents per million inhabitants and GDP per capita, a correlation coefficient of R = 0.631 was determined, which can be considered as large (significant) according to Cohen's criteria. Based on the obtained results, $R^2 = 0.398$ (coefficient of determination) and Adj.$R^2 = 0.298$ (corrected coefficient of determination), it is concluded that a total of 39.8% and 29.8% of changes in the dependent variable GDP per capita can be explained by changes in the independent variable, the number of patents per million inhabitants (Domazet et al., 2022). Based on the results of the ANOVA test F (1,6) = 3.973, p = 0.093, it can be concluded that the regression model at the $p < 0.050$ level was not statistically significant. According to Domazet et al. (2022, 199) "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 = 3.238 (SE B = 0.217), while the value of the standardized regression coefficient is $\beta = 0.631$ (Domazet et al., 2022). 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 Serbia.

In the first case, using the example of Hungary, 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 (Hungary)

<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>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 = 1.585</td><td>d = 1.306</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: the 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.

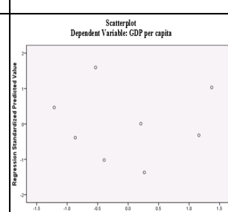
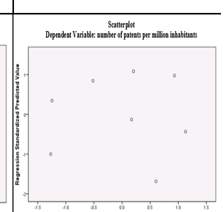
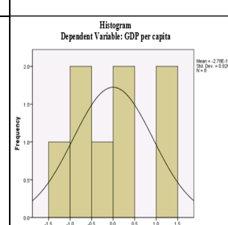
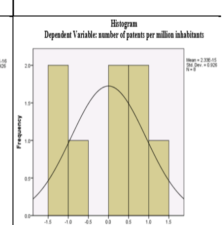
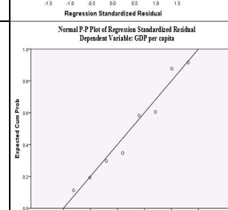
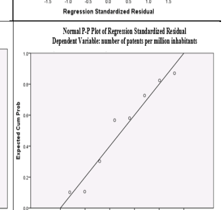
Ass. 4a. Based on the conducted Durbin Watson statistic and the obtained results shown in table 5, it was determined that there is the independence of observations when it comes to the number of patents per million inhabitants (d=1,585). The assumption is fulfilled.

Ass. 4b. Based on the conducted Durbin Watson statistic and the obtained results shown in table 2, it was determined that observations is no independent when it comes to the country's innovation index (d=1.306). The assumption is not met.

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. The assumption is fulfilled.

In another case, using the example of Hungary, 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 (Hungary)

<table>
<tr><th>Variable / assumption</th><th>Number of patents per million inhabitants (n = 8)</th><th>BDP 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 = 1.700</td><td>d = 2.291</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: the 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). The assumptions are not met.

Ass. 4. 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 the number of patents per million inhabitants (d=1.700) and BDP per capita (2.291). 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 heteroskedasticity 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
0.810[a]	0.656	0.599	0.01280

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

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

R	R Square	Adjusted R Square	SE of the Estimate
0.831[a]	0.690	0.639	0.02155

a. Predictors: (Constant), patent_transf
b. Dependent Variable: BDP_and_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	0.002	1	0.002	11.454	0.015[a]
Residual	0.001	6	0.000		
Total	0.003	7			

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

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

	Sum of Squares	df	Mean Square	F	p
Regression	0.006	1	0.006	13.377	0.011[a]
Residual	0.003	6	0.000		
Total	0.009	7			

a. Predictors: (Constant), patent_transf
b. Dependent Variable: BDP_and_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)	0.802	0.252		3.190	0.019
patent_transf	0.390	0.115	0.810	3.384	0.015

a. Dependent Variable: index_and_transf

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

	Unstandardized Coefficients		Standardized Coefficients	t	p
	B	Std. Error	Beta		
(Constant)	5.588	0.423		13.202	0.000
patent_transf	-0.710	0.194	-0.831	-3.657	0.011

a. Dependent Variable: BDP_and_transf

Source: the 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 = 0.810 was determined, which can be considered as large (significant) according to Cohen's criteria. Based on the obtained results R^2 = 0.656, (coefficient of determination) and Adj.R^2 = 0.599 (corrected coefficient of determination), it is concluded that a total of 65.6% and 59.9% 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 (Domazet et al., 2022). Based on the results of the ANOVA test F (1,6) = 11.454, p = 0.015, it can be concluded that the regression model at the $p < 0.050$ level was statistically significant. According to Domazet et al. (2022, 199), "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 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 was statistically significant at the $p < 0.050$ level and amounted to B = 0.802 (SE B = 0.252) (Domazet et al., 2022). Based on it, a regression equation can be derived in the form:

Innovation index = 0.802 + 0.390 x (number of patents per million inhabitants) (1)

This means that with each unit increase in the number of patents per million inhabitants, the innovation index of Hungary changes according to the formula 0.802 + 0.390 x (the number of patents per million inhabitants). In addition "the standardized beta regression coefficient in this case was β = 0.810, and can be qualified as large" (Domazet et al., 2022, p. 196).

In the simple linear regression model for the variables number of patents per million inhabitants and GDP per capita, a correlation coefficient of R = 0.831 was determined, which can be considered as large according to Cohen's criteria. Based on the obtained results R^2 = 0.690, (coefficient of determination) and Adj.R^2 = 0.639 (corrected coefficient of determination), it is concluded that a total of 69% and 63.9% of changes in the dependent variable, the GDP per capita, can be explained by changes in the independent variable, the number of patents per million inhabitants (Domazet et al., 2022). Based on the results of the

ANOVA test $F(1,6) = 13.377$, $p = 0.011$), it can be concluded that the regression model at the $p < 0.050$ level was statistically significant. According to Domazet et al. (2022, 199) "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 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 was statistically significant at the $p < 0.050$ level and amounted to B = 5.588 (SE B = 0.423) (Domazet et al., 2022). Based on it, a regression equation can be derived in the form:

BDP per capita = 5.588 – 0.710 x (number of patents per million inhabitants) (2)

This means that with each unit increase in the number of patents per million inhabitants, the innovation index of Hungary changes according to the formula 5.588 – 0.710 x (the number of patents per million inhabitants). In addition, "the standardized beta regression coefficient in this case was β = -0.831, and can be qualified as large" (Domazet et al., 2022, 196).

According to Domazet et al. (2022, p. 201), "the obtained negative value of the standardized regression coefficient β in this particular case means that with each unit" increase in the number of patents per million inhabitants, the GDP per capita decreases by a value of -0.810. Given that, according to the data, the number of patents per million inhabitants in Hungary decreased during the observed period, this means that with each unit of decrease in the number of patents per million inhabitants in Hungary, GDP per capita in the value of 0.810 occurred.

Conclusion

Empirical research confirms the existence of a relationship between the number of patents per million inhabitants and the country's innovation index only in the case of Hungary. In the other analyzed cases, no connections were found between the number of patents per million inhabitants on the one hand and the country's innovation index and GDP per capita growth on the other hand. The lack of influence of the number of patents per capita on the country's innovation index and BSP growth can be viewed from several angles.

First, an additional explanation of the obtained research results can be given by the European Innovation Scoreboard according to the efficiency of national innovation systems and the results of innovation activities. The survey is published every year by the European Commission, classifying countries into leaders in innovation, strong innovators, moderate innovators and modest innovators. In this ranking, Hungary is included in the group of countries that can be characterized as moderate innovators, while Serbia belongs to the group of weak innovators.

Second, it is necessary to verify the existence or establish the connections that innovations have with Hofstede's dimensions of national culture, because culture is considered one of the key factors in the innovation management process. The negative results obtained through the conducted research are partially explained by the high values of power distance that characterize the national cultures of Serbia and Hungary, as well as the negative relationship between this dimension of national culture and innovation.

Third, given the connection between national and organizational culture, and the fact that national culture provides a framework, i.e. a contextual milieu in which innovative activities can develop in different organizations, when interpreting the results, the organizational cultures of individual companies should also be taken into account. In terms of innovation activities, organizational culture can be defined as one of the key systems of the company, which is based on the values on which the principles and norms of company management rest. Therefore, any analysis that deals with innovation at the organizational level, i.e. at the company level, should take into account how the company plans its innovation activities, what kind of innovation infrastructure it has, what is the impact of innovation activities on the business of the company and how the company applies innovations. However, such an analysis would require the collection of primary data from companies from Serbia and Hungary, which may be a task in some future research.

Fourth, the impact of the operations of multinational companies and the inflow of foreign investments on innovation can be positive both for the innovation of the country where these companies start their operations, and for its economy as a whole. Bearing this in mind, it is legitimate to ask the question to what extent foreign investments improved the development of the innovation systems of Serbia and Hungary, enabled the smooth development of patents, and how much this affected innovation and GDP growth.

If the national innovation systems of Serbia and Hungary are compared, it can be concluded that there are problems in the cooperation between the academic community and the business sector, that the demand for innovation in their economies is small, and the systems themselves are underfunded and ineffective. With that in mind, the result obtained is not surprising. Even if these countries had a higher average number of patents per capita, invested far more in the field of research and development, and employed a far greater number of researchers, it would not give a significant result. This happens due to unresolved issues of cooperation between science and business, the successful application of patents in the business sector, both industry and services, and the issue of low demand for innovation.

The information obtained through the conducted empirical research primarily carries a warning for decision makers regarding the efficiency of national innovation systems, absorption possibilities and the demand for innovations at the level of national economies. In this sense, the primary task for decision-makers concerns raising awareness of the importance of innovations and increasing demand for them at the level of the national economy. However, even if the studied countries have a much higher number of patents per million inhabitants than the current figures, this will not affect the increase in innovation of the economy and the growth of well-being if (a) patents do not find a place for their application, (b) business entities do not have the capacity for their application, and (c) until everyone understands that the application of those patents enables them to achieve better business results.

The conducted research also has several limitations. The first limitation of this research is related to the number of countries included in the research, considering that the analysis was done only for Serbia and Hungary. A recommendation for future researches is to include three or more countries that belong to one region in the analysis. Another limitation of this research was related to the number of indicators that were analyzed. In this research, the influence of the number of patents on the growth of innovation and economic growth was tested, while some other indicators (e.g. production growth) should be included in some future research. The third limitation of this research is the time period covered by the analysis, which in this case was from 2008 to 2018. The recommendation to researchers is to use a longer time series (20 or more years) in some subsequent research.

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References

Abibo, A., Muchie, M, Sime, Z., Ezezew, W. (2022). Analysis of the relationship between innovation and Ethiopian economic growth. *Research Square*, 4. https://doi.org/10.21203/rs.3.rs-1576170/v1.

Alheet, A. F., & Hamdan, Y. (2020). Evaluating innovation-driven economic growth: a case of Jordan. *Entrepreneurship and Sustainability Issues 7*(3), 1793-1794. https://doi.org/10.9770/jesi.2020.7.3(23)

An, X., Li, J., Xu, S., Chen, L., & Sun, W. (2021). An improved patent similarity measurement based on entities and semantic relations. *Journal of Informetrics*, *15*(2). https://doi.org/10.1016/j.joi.2021.101135

Androniceanu, A.M., Kinnunen, J., Georgescu, I., & Androniceanu, A. (2020). A multidimensional approach to competitiveness, innovation and well-being in the EU using canonical correlation analysis. *Journal of Competitiveness*, *12*(4), 5–21. https://doi.org/10.7441/joc.2020.04.01

Biggi, G., & Giuliani, E. (2021). The noxious consequences of innovation: what do we know? *Industry and Innovation*, 28(1), 19-41. https://doi.org/10.1080/13662716.2020.1726729

Chang, X., McLean, R. D., Zhang, B., & Zhang, W. (2018). Do patents portend productivity growth? Global evidence from private and public firms. *Global Evidence from Private and Public Firms.* http://dx.doi.org/10.2139/ssrn.2371600

Czarnitzki, D., & Toole, A. A. (2011). Patent protection, market uncertainty, and R&D investment. *The Review of Economics and Statistics*, *93*(1), 147-159. http://dx.doi.org/10.2139/ssrn.925621

Daimer, S., Havas, A., Cuhls, K., Yorulmaz, M., & Vrgovic, P. (2021). Multiple futures for society, research, and innovation in the European Union: jumping to 2038. *Journal of Responsible Innovation*, 8(2), 148-174. https://doi.org/10.1080/23299460.2021.1978692

Disoska, E. M., Tevdovski, D., Toshevska-Trpchevska, K., & Stojkoski, V. (2020). Evidence of innovation performance in the period of economic recovery in Europe. *Innovation: The European Journal of Social Science Research*, 33(3), 280-295. https://doi.org/10.1080/13511610.2018.1524288

Domazet, I., Zubović, J., & Lazić, M. (2018). Driving factors of Serbian competitiveness: digital economy and ICT. *Strategic management*, *23*(1), 20-28. http://doi.org./10.5937/StraMan1801020D

Domazet, I., Marjanović, D., Ahmetagić, D., & Bugarčić, M. (2021). The impact of innovation indicators on increasing exports of high technology products. *Ekonomika preduzeća*, *69*(1-2), 31-40. https://doi.org/10.5937/EKOPRE2102031D

Domazet, I., Marjanović, D., & Ahmetagić, D. (2022). The Impact of High-Tech Products Exports on Economic Growth: The Case of Serbia, Bulgaria, Romania and Hungary. *Економика предузећа*, *70*(3-4), 196-201. https://doi.org/10.5937/EKOPRE2204191D

Donges, A., Meier, J.M., & Silva, R.C. (2022). The impact of institutions on innovation. http://dx.doi.org/10.2139/ssrn.2815541

Falk, N., & Train, K. (2017). Patent valuation with forecasts of forward citations. *Journal of Business Valuation and Economic Loss Analysis*, *12*(1), 101-121. https://doi.org/10.1515/jbvela-2016-0002

Frietsch, R., Neuhäusler, P., Jung, T., & Van Looy, B. (2014). Patent indicators for macroeconomic growth — the value of patents estimated by export volume. *Technovation*, *34*(9), 546-558. https://doi.org/10.1016/j.technovation.2014.05.007

Hai, B., Yin, X., Xiong, J., & Chen, J. (2022). Could more innovation output bring better financial performance? The role of financial constraints. *Financial Innovation*, 8(1), 1-26. https://doi.org/10.1186/s40854-021-00309-2

Hsieh, C. H. (2013). Patent value assessment and commercialization strategy. *Technological forecasting and social change*, *80*(2), 307-319. https://doi.org/10.1016/j.techfore.2012.09.014

Kicová, M. (2019). Enterprise's process innovations in the context of enterprise's financial performance. *Strategic Management*, 24(3), 3-13. https://doi.org/10.5937/StraMan1903003K

Kim, J. W. (2011). The economic growth effect of R&D activity in Korea. *Korea and the World Economy*, *12*(1), 25-44.

Law, S. H., Sarmidi, T., & Goh, L. T. (2020). Impact of innovation on economic growth: evidence from Malaysia. *Malaysian Journal of Economic Studies*, *57*(1), 113-132. https://doi.org/10.22452/MJES.vol57no1.6

Lebel, L., Navy, H., Jutagate, T., Akester, M. J., Sturm, L., Lebel, P., Lebel, B. (2021). Innovation, practice, and adaptation to climate in the aquaculture sector. *Reviews in Fisheries Science & Aquaculture*, *29*(4), 721-738. https://doi.org/10.1080/23308249.2020.1869695

Lee, S. Y., Florida, R., & Gates, G. (2010). Innovation, human capital, and creativity. *International Review of Public Administration*, *14*(3), 13-24. https://doi.org/10.1080/12294659.2010.10805158

Li, R., Fu, L., & Liu, Z. (2020). Does openness to innovation matter? The moderating role of open innovation between organizational ambidexterity and innovation performance. *Asian Journal of Technology Innovation*, 28(2), 251-271. https://doi.org/10.1080/19761597.2020.1734037

Lomachynska, I., & Podgorna, I. (2018). Innovation potential: impact on the national economy's competitiveness of the EU developed countries. *Baltic Journal of Economic Studies*, *4*(1), 262-270. https://doi.org/10.30525/2256-0742/2018-4-1-262-270

Marjanović, D., Ahmetagić, D., & Beraha, I. (2019). Comparative analysis of high technology exports and selected innovation indicators for Serbia and CEE countries. *Economic Analysis*, *52*(2), 93-103. https://doi.org/10.28934/ea.19.52.2.pp93-103

Maskus, K. E., Milani, S., & Neumann, R. (2019). The impact of patent protection and financial development on industrial R&D. *Research Policy*, *48*(1), 355-370. https://doi.org/10.1016/j.respol.2018.09.005

Nanyangwe, C. N., Wang, H., & Cui, Z. (2021). Work and innovations: the impact of self-identification on employee bootlegging behaviour. *Creativity and Innovation Management*, 30(4), 713-725. https://doi.org/10.1111/caim.12455

O'Neale, D. R., & Hendy, S. C. (2012). Power law distributions of patents as indicators of innovation. *PLoS ONE*, *7*(12). https://doi.org/10.1371/journal.pone.0049501

Rambe, P., & Khaola, P. (2022). The impact of innovation on agribusiness competitiveness: the mediating role of technology transfer and productivity. *European Journal of Innovation Management*, 25 (3), 741-773. https://doi.org/10.1108/EJIM-05-2020-0180

Sampat, B., & Williams, H. L. (2019). How do patents affect follow-on innovation? Evidence from the human genome. *American Economic Review*, *109*(1), 203-236. https://doi.org/10.1257/aer.20151398

Sandrini, L. (2022). Innovation, competition, and incomplete adoption of a superior technology. *Economics of Innovation and New Technology*, 1-21. https://doi.org/10.1080/10438599.2021.2024432

Scoresby, R. B., Withers, M. C., & Ireland, R. D. (2021). The effect of CEO regulatory focus on changes to investments in R&D. *Journal of product innovation management*, 38(4), 401-429. https://doi.org/10.1111/jpim.12591

Sharma, R., Paswan, A. K., Ambrammal, S. K., & Dhanora, M. (2018). Impact of patent policy changes on R&D expenditure by industries in India. *The Journal of World Intellectual Property*, *21*(1-2), 52-69. https://doi.org/10.1111/jwip.12090

Strielkowski, W., Samoilikova, A., Smutka, L., Civín, L., & Lieonov, S. (2022). Dominant trends in intersectoral research on funding innovation in business companies: a bibliometric analysis approach. *Journal of Innovation & Knowledge*, 7 (4). https://doi.org/10.1016/j.jik.2022.100271

Tanane, O. (2020). Roles of patents in economic development and integration. *ECONOMICS - Innovative and Economic Research*, *8*(1), 23-30. https://doi.org/10.2478/eoik-2020-0008

The World Intellectual Property Organization. (2019). Country profile - Serbia, Hungary, Retrieved November 05, 2022 from: https://www.wipo.int/ipstats/en/statistics/country_profile/

Yesilay, R. B., Ar, I. M., & Temel, S. (2015). The relationship between direct government support for R&D and patents in emerging economies: a Turkish case study. *International Journal of Innovation and Technology Management*, *12*(05), 1. https://doi.org/10.1142/S0219877015500212

World Bank. (2019). Total population by country - Serbia, Hungary. Retrieved November 05, 2022 from: https://data.worldbank.org/indicator/SP.POP.TOTL

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