European Research Studies Journal
Volume XXIV, Special Issue 3, 2021

pp. 402-418

A Preliminary Analysis of the Relationship between Economic Growth and Selected Innovativeness Indicators on the Example of Four European Union Countries

Submitted 04/07/21, 1st revision 01/08/21, 2nd revision 21/08/21, accepted 15/09/21

Janusz Myszczyszyn[1], Irena Łącka[2],
Sylwia Gołąb[3], Beata Będzik[4], Błażej Suproń[5]

Abstract:

Purpose: *The article aimed to determine the general relationships between economic growth and development and selected innovativeness indicators in two countries belonging to the leaders of innovativeness in comparison with two countries of Central and Eastern Europe representing moderate innovators.*
Design/Methodology/Approach: *Cluster analysis (agglomeration method), elements of descriptive statistics, correlation calculus, and the ADF test were used to study the stationarity of the variables initially.*
Findings: *The results have shown that the analyzed innovativeness indicators have fluctuated to varying degrees, although in many cases, Poland and Hungary demonstrated high rates of growth, which could suggest a catching-up effect. Although the correlation coefficients between the levels of economic growth and development and the analyzed innovativeness variables were in many cases significant (usually positive), stationarity tests showed that the variables are in the vast majority non-stationary, which is a reason for further research when trying to build an econometric model.*
Practical Implications: *A general analysis of the data indicated that the following stages of the study would require an expansion to include a cointegration account and determine the interrelationship of variables in both the short and long term, using autoregressive models.*
Originality/Value: *Preliminary analysis of economic growth factors using descriptive statistics and correlation coefficients for selected countries (Sweden, the Netherlands, Poland, Hungary) based on available source data from OECD.*

Keywords: *Economic growth, innovativeness, indices, European Union, selected countries, ADF analysis.*

JEL classification: *O11, O32, O33, O52.*

Research Type: *Research article.*

[1]*West Pomeranian University of Technology in Szczecin, jmyszczyszyn@zut.edu.pl;*
[2]*West Pomeranian University of Technology in Szczecin, Poland, irena.lacka@zut.edu.pl;*
[3]*West Pomeranian University of Technology in Szczecin, Poland, sylwia.golab@zut.edu.pl;*
[4] *West Pomeranian University of Technology in Szczecin, Poland, beata.bedzik@zut.edu.pl;*
[5]*West Pomeranian University of Technology in Szczecin, Poland, bsupron@zut.edu.pl;*

1. Introduction

In 2019, even before the outbreak of the COVID-19 pandemic, the European Union adopted a new development strategy called the "Green Deal." It responds to new economic, environmental, technological, and social challenges facing the global economy. "Green Deal" is an action plan for a sustainable Community economy. It is a document with ambitious goals to transform the European Union into a modern, resource-efficient, and competitive economy to achieve climate neutrality by 2050 (European Commission, 2019; 2021). The adopted document has not lost its relevance in a pandemic environment. The actions and goals outlined in it have become even more critical to find ways for the European Union and its member states to recover from the social and economic crisis caused by the coronavirus pandemic. The "Next Generation EU" (a strategic and financial plan for the period 2021-2027 for recovery from the socio-economic problems caused by the pandemic), which is being prepared for approval, identifies a modern and more sustainable Europe as an objective. Key elements of this modernization plan include investment in research and development, climate security and a waste-free (circular) economy, digitalization of the economy, and investment in health and resilience.

The indicated objectives require intensification of research and development work, creation and implementation of innovations, improving the quality of human capital, and increasing cooperation between science and economy in innovative activities and between member states. Currently, the countries of the European Union show great diversity in the potential and level of innovativeness. This affects the possibilities of creating a basis for sustainable development, achieving climate neutrality, and other strategic objectives of the grouping. This is a consequence of the technological gap between the "old" and "new" EU countries. Despite the passage of 17 years since the integration of most CEE countries into the Community, a large part of the countries in this group are "moderate" innovators (Croatia, the Czech Republic, Hungary, Latvia, Lithuania, Poland, Slovakia, Slovenia) and "modest" innovators (Bulgaria and Romania). This is confirmed by their summary innovation indicators, much lower than the average indicators for the European Union and the "leaders" in innovation (Sweden, Finland, Denmark, the Netherlands, Luxembourg) (European Union, 2020).

This became an inspiration for the authors to verify whether this level of innovativeness and its determinants affect economic growth or whether the rate of economic growth of "moderate" innovators impedes achieving higher aggregate innovativeness indicators. The aim of this study was the examination of the relationship between economic growth and development and selected innovativeness indicators on the example of four European Union countries from the European Innovation Scoreboard 2020 (European Union, 2020) - two being innovation leaders (Sweden and the Netherlands and two moderate innovators (Poland and Hungary). The research was conducted for 2004-2018, using statistical data from the OECD Main Science and Technology Indicators database (https://stats.oecd.org/). The

research used literature analysis, cluster analysis, elements of descriptive statistics, correlation calculus, and the ADF stationarity test.

2. Literature Review

Economic growth is the foundation of the development of socio-economic systems (Solow, 1956; Mankiw, Romer, and Weil, 1992; Barro, 1991; Rodionov, Kudryavtseva, and Skhvediani, 2018) and an element of any formulated development strategy. It represents both the goal of the efforts made and a means of leading to an increase in the welfare of the population, regardless of socio-economic development. For several decades, the simple reserves of economic growth in the world economy have already been exhausted, hence the increased efforts of researchers looking for its generators. Among the main determinants of economic growth are population growth, the development of the financial sector, macroeconomic conditions, trade policy, socio-political environment, but also research and development expenditures, their volume, and the subject structure (Griliches, 1992; 1998; Park, 1995; Samini and Alerrasoul, 2009; Snowdon and Vane, 2005; Myszczyszyn, 2020).

The study of the relationship between economic growth and technological progress (innovation) was initiated by Solow (1956), indicating a long-term relationship between these categories. The theoretical models of Solow (1956), Romer (1986), Grossman (2009), and Aghion and Howitt (1992; 2009) provide the basis for other researchers to search for the relationship between innovations and economic growth (Nadiri, 1993; Wong, Ho, and Autio, 2005). Nadiri's (1993) research showed that economic growth is determined by the growth rate of exogenous character innovations. Nadiri emphasized that in a globalizing world economy, technology diffusion within the international technology transfer on economic growth increases. In Romer's (1986) endogenous growth model, on the other hand, it is endogenously determined by the decisions of subjects driven by their desire for profits from entrepreneurship and innovation processes.

Empirical studies on the links between economic growth and innovations sometimes confirm the relationships indicated in the theoretical literature (Schumpeter, 1912; King and Levine, 1993; Ulku, 2004; Agenor and Neanidis, 2015). However, sometimes they do not provide convincing evidence. Aghion, Bloom, Blundell, Griffith, and Howitt (2005) and Aghion, Boustan, Hoxby, and Vandebussche (2009) note the importance of innovation and education in maintaining economic growth and competitiveness. Some researchers point out that economic growth is stimulated by innovation activities directly and indirectly through other macroeconomic factors that support a country's innovation potential (Furman *et al.*, 2002; Hassan and Tucci, 2010). Neuhaus (2006) emphasized the importance of foreign investment for economic growth in countries transforming socio-economic systems, and Mattalia (2012) saw long-term links between human capital accumulation through education and endogenous economic growth. Additional factors contributing to this growth were

research and development works in the scope of information and communication technology (ICT) and adequately equipped laboratories.

Extensive research on the relationship between economic growth, R&D spending, innovation in 20 OECD and ten non-OECD countries was conducted by Ulku (2004). The data analysis from 1981-1997 confirmed the impact of innovation on GDP per capita regardless of the level of development of the economy. However, an increase in innovativeness through increased research and development (R & R&D) expenditures was possible only in developed countries. In addition, OECD countries were able to support innovativeness by using the know-how of other OECD members. These studies indicated that economic growth was determined by innovation, but only in the short term.

Ciborowski and Skrodzka (2019) presented the results of a study on the relationship between international technology transfer (ITT), innovations, and the level of economic development of EU countries in 2008-2017, which aimed to develop and verify a soft model. The results showed a positive impact of international technology transfer and innovativeness on economic development in the analyzed EU countries. In addition, the strength of the impact of innovations was greater than ITT, and the relationship between these categories was positive. In the study from 2020, the cited authors (Ciborowski and Skrodzka, 2020) also identified the most critical factors affecting international technology transfer and innovations. The first category was driven primarily by technological cooperation with U.S., China, and India partners. In contrast, the stimulation of innovation in European countries was determined by patents, employment in knowledge-intensive industries, and business spending on R&D.

In contrast, Pessoa's (2007) analysis for Sweden and Ireland found no strong relationship between R&D spending and economic growth. This concludes that economic growth is derived from many different factors, including institutional factors (de Haan and Sturm, 2000). Westmore's (2013) findings for 1980-2008 covering 19 OECD countries did not confirm the direct impact of R&D stimulus activities and patent protection rights on aggregate productivity growth, although they did show their impact on innovation activities in the private sector. In contrast, research by Pece, Simona, and Salisteanu (2015) on the factors of economic growth in Central and Eastern European countries revealed that education and the quality of human capital and knowledge transfer strongly affect sustainable economic growth.

Czarnitzki and Toivanen (2013), on the other hand, proved a positive effect of public R&D investment on private investment, the effects of which varied in terms of the experience of companies' innovation activity and the level of labor productivity in past periods. Their study examined the relationship between economic growth and R&D investment in Germany and Belgium. In contrast, a study by Pop Silaghi, Alexa, Jude, and Litan (2014) found that for the Central and Eastern European countries (Bulgaria, Czech Republic, Estonia, Latvia, Lithuania, Hungary, Poland, Romania, Slovenia, and

Slovakia), public R&D spending did not show a statistic, significant ally effect on economic growth rates between 1998 and 2008. Their analysis shows that economic growth in these countries was affected by companies' investment in R&D.

Conclusions indicating a long-run effect of tax incentives on R&D activities were drawn by Minniti and Venturini (2013) based on an analysis of nineteen industries in the U.S. between 1975 and 2000. Their study indicated that subsidies on research activity increase the R&D efforts and economic growth rates, but only temporarily. Analysis of the literature confirms that R&D policies prove the validity of the endogenous growth theory rather than the semi-endogenous growth theory (Pece, Simona, and Salisteanu, 2015).

Petrariu, Bumbac, and Ciobanu (2013) examined the relationship between economic growth and innovation in CEE countries using a panel model for this analysis. Their result was the constatation that the critical support for innovativeness is the level of development of a given economy, as seen in the allocation of R&D spending. Moreover, although the researchers noticed significant economic growth in the conducted research, it was not the result of the innovation process. As Slepov, Burlachkov, Danko, Kosov, Volkov, Grishina, and Sekerin (2017) point out, the peculiarity of the dynamic model of economic growth is the existence of a mechanism of capital accumulation and innovation generation, and, consequently, the continuous updating of the technological base and product series.

3. Research Methodology

An examination of the causal relationship between economic growth and innovativeness indicators was conducted using selected variables. The following were taken as counterparts of the economic situation changes**:**

- gross domestic product (in current prices USD PPP),
- gross domestic product per capita (in USD PPP),
- gross domestic product in national currencies.

The indicators that determine innovativeness were represented by six variables used to indicate the Summary Innovativeness Index (SII) to measure the innovativeness of countries belonging to the European Union and selected countries of the world. The innovativeness ranking of countries is detailed in the annual European Innovation Scoreboard (European Union, 2020). This complex index is derived from sub-indices assigned to two categories. One includes indices of the contribution to innovation activity, and the other includes indices showing the effects.

Indices are assigned to such areas of innovativeness analysis as catalysts (human resources, open, excellent, and attractive research systems, and funding and support), companies activities (companies investments, linkages and entrepreneurship, and intellectual assets), and outcomes (innovators and economic impacts). From these

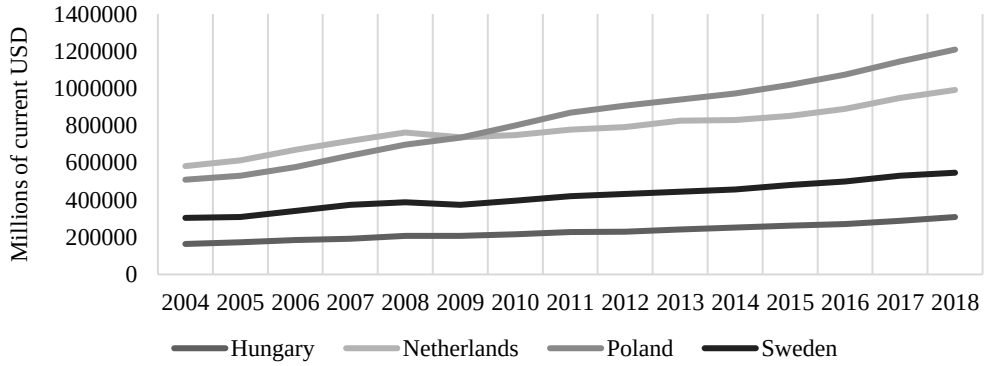
groups of indices come those that were found to be usable for studying the relationship of economic growth to specific innovativeness indices. From the first group of "input" indices, the following were selected: gross domestic R&D expenditures, business R&D expenditures, higher education R&D expenditures, number of people employed in R&D (total R&D personnel). From the group of "output" indices, i.e., the evaluation of results, such measures as the number of patent applications under the PCT procedure (one international application under an international convention administered by the World Intellectual Property Organization, WIPO) and the number of triadic patents (patents obtained simultaneously in the USA, EU and Japan) were used. For the research objective, the following variables were analyzed:

- GDP_CP - gross domestic product (current prices USD PPP),
- GDP_NC - gross domestic product (national currency),
- GDP_PC - gross domestic product per capita,
- GERD_CP - gross domestic expenditure on R&D (constant prices USD PPP),
- GDE_RD - Gross national expenditure on research and development (current prices USD PPP),
- BERD_CP - enterprise expenditure on R&D (current prices USD PPP),
- HEE_RD - higher education spending on research and development (HERD) (current prices USD PPP),
- T_RD_P - total R&D personnel,
- NP_AF - number of PCT patent applications,
- NTPF - number of triadic patents.

The graphical form of the time series of the variables under study is shown in Figures 1-9. Using cluster analysis, four countries were selected for further analysis under the agglomeration method. The first group contained two European Union countries classified as innovativeness leaders and at the same time characterized by a similar level of the examined indices. The second group consisted of two countries from Central and Eastern Europe, which have been in the European Union since 2004 and belong to the Visegrad Group. The European Innovation Scoreboard 2020 (European Union, 2020) is classified as moderate innovators and characterized by a similar level of the examined indices. As a result of the analysis, Sweden and the Netherlands were classified in group one, while Poland and Hungary in group two.

Among the countries under study, the highest gross domestic product growth expressed in USD current prices was recorded in Poland (growth of 237.3% between 2004 and 2018) and Hungary (growth of 188.2%). In contrast, the GDP of the Netherlands and Sweden increased by 170.3% and 179.8%, respectively, during the period under review. Poland at the same time had the highest average annual GDP growth at 6.4%. Thus, this value was by 2.5 p.p. higher than the average annual GDP growth in the Netherlands, which had the lowest growth dynamics in the examined period (Figure 1).

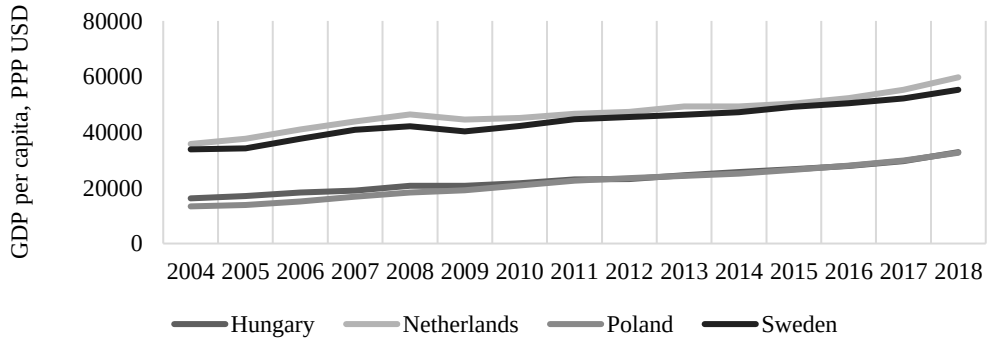
Figure 1. *The value of the variable Gross Domestic Product (current PPP USD)*



Source: *Own study on the basis of the OECD database.*

The selected countries over the period 2004-2018 were characterized by stable growth of gross domestic product per capita expressed in USD at current prices. The most dynamic GDP growth was recorded in Poland with an average annual growth rate of 6.6% and Hungary with an annual growth rate of 5.2%. The smallest GDP growth occurred in the Netherlands, where the average annual growth rate was 3.8% (Figure 2).

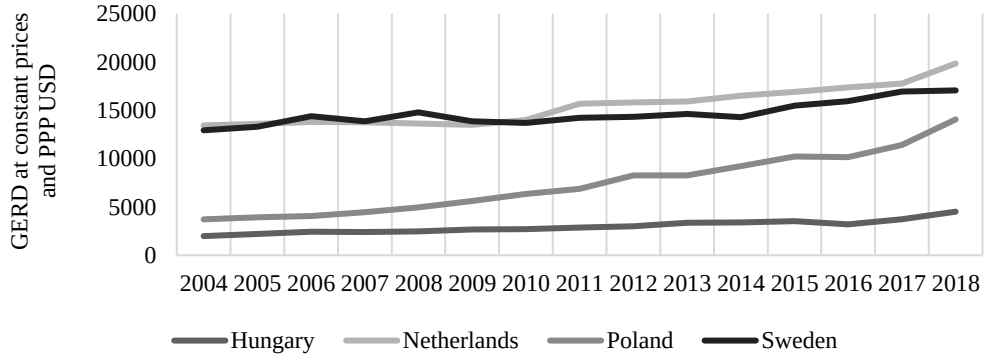
Figure 2. *The value of the variable GDP per capita (current PPP USD)*



Source: *Own study on the basis of the OECD database.*

Gross domestic expenditure on R&D expressed in USD at constant prices increased in all the countries studied between 2004 and 2018 (Figure 3). The highest growth rate of GERD occurred in Poland, where an increase of 378.2% was recorded (average annual growth of 10.2%). The lowest growth rate was observed in Sweden, where the value of gross domestic expenditure on R&D in the analyzed period increased by 131.9% (average annual growth of 2.1%).

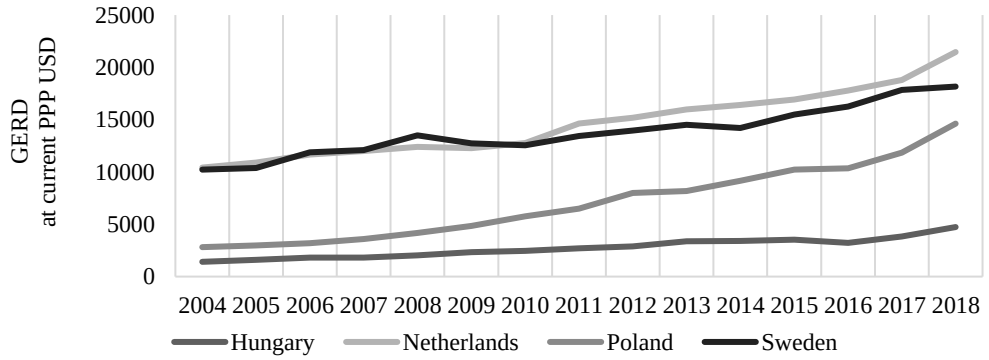
Figure 3. *The value of the variable Gross Domestic Expenditure on R&D at constant prices and PPP USD*



Source: *Own study on the basis of the OECD database.*

In assessing the determinants of innovativeness of the studied countries, gross domestic expenditure on research and development (GERD) in USD at current prices was also analyzed. This index increased the fastest in Poland, where its value increased nearly five times between 2004 and 2018. The average annual growth of GERD in this country was 12.7%. In the case of Hungary, the value of the indicated variable increased more than three times. However, the lowest growth dynamics of this index occurred in Sweden - its average annual increase amounted to 4.3% (Figure 4).

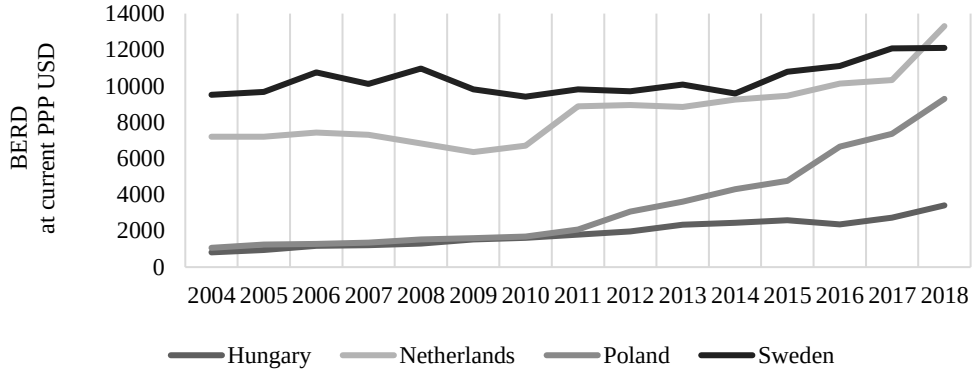
Figure 4. *The value of the variable Gross Domestic Expenditure on R&D (GERD) at current PPP USD*



Source: *Own study on the basis of the OECD database.*

Companies' expenditures on R&D expressed in current prices increased the most in Poland (871.4%) and Hungary (418.9%). The smallest increase in this index was observed in Sweden (127.3%). The high growth of BERD in Poland and Hungary was also connected with high dynamics of average annual growth, which amounted to 17.4% and 11.1%, respectively. In the Netherlands and Sweden, the average annual growth was maintained at 5.1% and 2.2% (Figure 5).

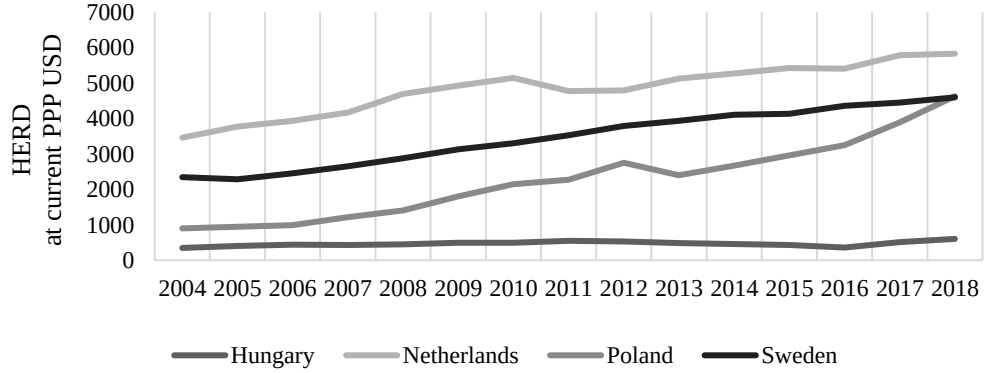
Figure 5. *Business enterprise R&D expenditure (current PPP USD)*



Source: *Own study on the basis of the OECD database.*

Between 2004 and 2018, all countries studied increased their higher education research and development (HERD) expenditures measured in USD at current prices. The growth of these expenditures was particularly evident in Poland, as in this country, they increased fivefold over the period under study (average annual growth rate was 12.9%). On the other hand, in the analyzed period, the smallest increase of HERD was recorded in the Netherlands - by 168.5% (average annual growth of 3.9%). Changes of this index are presented in Figure 6.

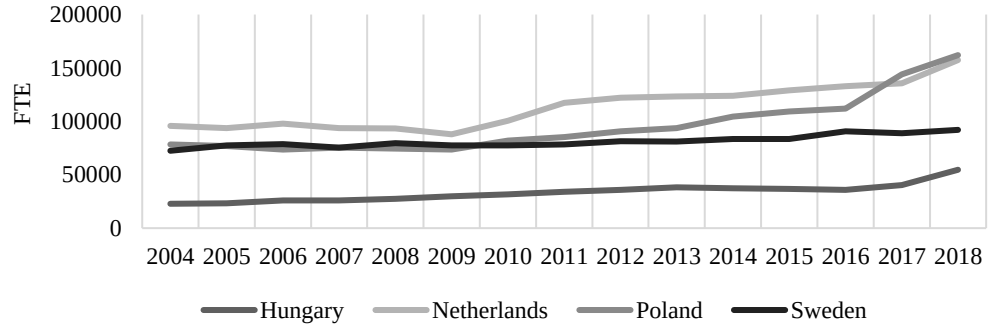
Figure 6. *The value of the variable Higher Education Expenditure on R&D (HERD) at current PPP USD*



Source: *Own study on the basis of the OECD database.*

The following innovativeness index from the input category is the size of personnel employed in R&D activities. The analysis of data on this variable in the studied countries also shows a dynamic growth of this variable between 2004 and 2018. To the greatest extent, the size of the examined index increased in Hungary (239.4%) and Poland (206.7%). The smallest increase in the number of people employed in R&D activities occurred in Sweden (an increase of 27.1%). Hungary also maintained the highest average annual growth of the variable under study at 6.8% (Figure 7).

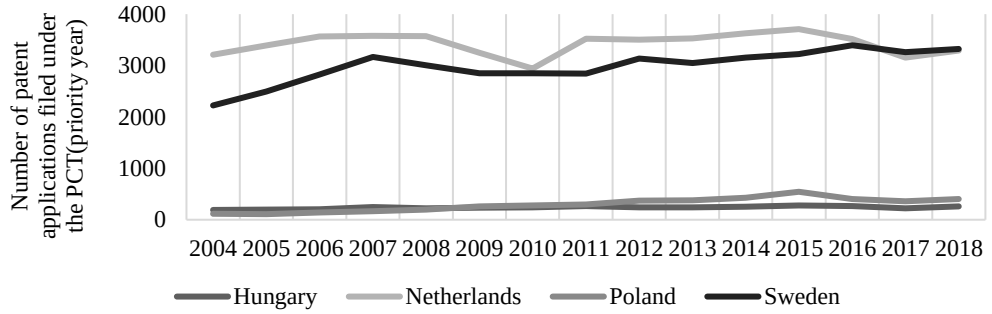
Figure 7. *Total R&D personnel (FTE)*



Source: *Own study on the basis of the OECD database.*

To evaluate the results of innovation activities, the behavior of two indices in terms of patents was analyzed. The first one, i.e., the number of PCT patent applications in the studied countries, showed an increasing trend between 2004 and 2018 (Figure 8). In Sweden and the Netherlands, the number of applications was nearly fifteen times higher than in Poland and Hungary. During this period, there was also an increase in the dynamics of the number of submissions in the post-socialist countries, which belong to the moderate innovators. In Poland, during the examined period, the dynamics index of this variable amounted to 341.3% (average annual growth of 10.5%), and in Hungary - 135.9%. On the other hand, in the Netherlands, where most of such notifications were made, the average annual growth rate was 0.4% (the total dynamics was 102.4%).

Figure 8. *The value of the variable number of patent applications filed under the PCT (priority year)*

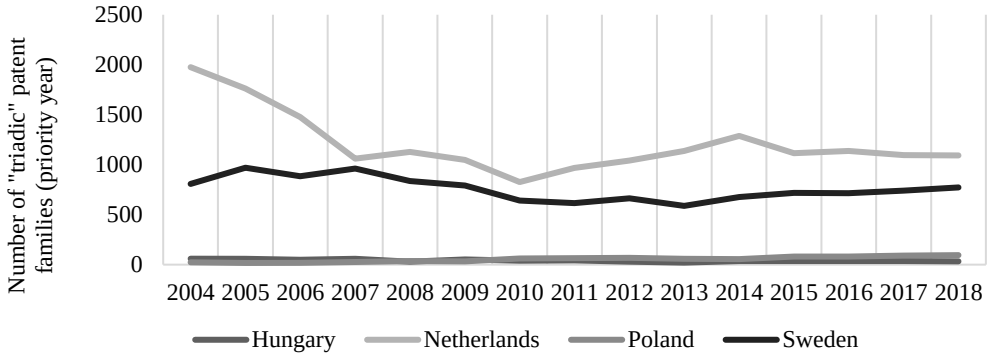


Source: *Own study on the basis of the OECD database.*

The second index of innovation performance analyzed was the number of "triadic" patents (obtained simultaneously at the European, Japanese, and American Patent Office, i.e., at the EPO, JPO, and the USPTO). During the period studied, there was a decrease in this variable in countries among the innovation leaders. In the Netherlands, 44.1% fewer such patents were obtained during the period under study, while in Sweden, 4.2% fewer were obtained. However, an increase in this index was recorded

in Poland, were compared to 2004 the number of triadic patents nearly tripled (Figure 9).

Figure 9. *The value of the variable number of "triadic" patent families (priority year)*



Source: *Own study on the basis of the OECD database.*

To achieve the research objective, the time series of the presented variables, which included annual data from 2004 to 2018, were subjected to detailed statistical analysis. The periodicity of the data resulted from the annual frequency of publication of information on the variables under study. The beginning of the research period was determined by the length of the data publication period (the first information on the analyzed values for all the studied countries was published in 2004).

In the first stage of the study, selected descriptive statistics were analyzed based on the values of individual variables (Table 1). These were: the observed smallest and the most significant value, the range, the mean, the median, the standard deviation, the coefficients of asymmetry (skewness), and concentration (kurtosis). Kurtosis, which is used to measure the shape of the distribution of trait values, indicates that most of the time series under consideration was characterized by a slight deviation from the normal distribution. In twelve cases, there is left-handed asymmetry. The general analysis indicates that the values of asymmetry coefficients are within the limits required for normal distribution for most variables.

The values of Pearson's linear correlation coefficients are summarized in Table 2. The variables studied showed strong relationships of a correlative nature. In the NTPF variable and GDP_NC, GDP_CP, and GDP_PC data, the correlation coefficient took negative values, which may be puzzling and will be subject to more detailed analysis in the future. The negative relationship did not occur for the analyzed variable only in the case of Poland. The strength of some correlative relationships varied depending on the analyzed country. The lowest correlation was obtained for the following variables:

- HEE_RD i NP_AF in the case of the Netherlands and Hungary,
- NP_AF with the other variables in the case of the Netherlands,
- NTPF i GERD_CP in the data on Sweden.

Table 1. *Descriptive statistics of increases in values of the analyzed variables*

Country	HUN	NLD	POL	SWD	HUN	NLD	POL	SWD	HUN	NLD	POL	SWD
Variable	GERD_CP				GDE_RD				BERD_CP			
Minimum	1980	13439	3718	12931	1413	10421	2814	10226	814	6353	1066	9413
Maximum	4510	19849	14059	17061	4734	21463	14622	18162	3410	13309	9292	12105
Range	2530	6411	10342	4129	4733	21464	14622	18163	2596	6957	8226	2691
Average	2963	15437	7436	14648	2747	14637	7084	13813	1881	8546	3393	10368
Median	2864	15684	6885	14324	2708	14634	6487	13487	1788	8852	2075	10087
Std Dev	646.7	1905.3	3021.5	1182.7	911.5	3118.9	3505.1	2291.7	722.17	1782.4	2503.97	860.23
Skewness	0.64	0.69	0.53	0.78	0.38	0.52	0.51	0.36	0.39	1.17	1.16	0.94
Kurtosis	0.48	-0.13	-0.43	0.09	-0.36	-0.41	-0.55	-0.32	-0.58	1.79	0.37	-0.17
Variable	HEE_RD				NP_AF				NTPF			
Minimum	347	3461	899	2285	190	2942	108	2224	20	826	18	588
Maximum	602	5831	4630	4599	277	3709	544	3395	60	1975	95	970
Range	254	2370	3731	2314	87	767	435	1171	40	1149	77	382
Average	465	4836	2282	3464	237	3424	296	2987	41	1210	54	758
Median	460	4933	2277	3533	242	3514	294	3051	36	1116	59	742
Std Dev	66.6	695.4	1077.4	777.3	25.1	204	125.5	306.2	11.4	294.9	25.9	113.7
Skewness	0.1	-0.48	0.5	-0.14	-0.41	-0.82	0.06	-0.98	0.32	1.42	0.01	0.42
Kurtosis	-0.1	-0.58	-0.22	-1.47	-0.61	0.24	-0.84	1.14	-0.67	2.16	-1.4	-0.59
Variable	T_RD_P				GDP_PC				GDP_CP			
Minimum	22826	87874	73554	72459	16230	35780	13343	33831	582518	509395	304232	164029
Maximum	54654	157389	161993	92011	32834	59727	32611	55243	991875	1208904	546885	308700
Range	31828	69515	88439	19552	16604	23947	19268	21413	409357	699509	242653	144671
Average	33303	113643	95679	81180	23148	46950	21985	44118	783006	842016	420294	228566
Median	33960	117436	85219	79549	23000	46599	22554	44609	777881	869770	421516	228296
Std Dev	7919.1	19839.7	25930.3	5460.2	4602.4	6050.4	5691.8	6032.2	109810.4	215472	72168.3	41272.7
Skewness	0.96	0.47	1.37	0.64	0.4	0.12	0.12	-0.04	0.03	0	0.09	0.25
Kurtosis	2.1	-0.53	1.75	-0.19	-0.4	0.3	-0.91	-0.55	-0.19	-1.12	-0.8	-0.69

Source: *Own study on the basis of the OECD database.*

Despite the strong relationship between the variables, the authors also examined the analyzed data's stationarity for one of the countries. The data were previously logarithmized. The procedure of testing stationarity is essential because, in the absence of stationarity of variables, one can wrongly conclude the interdependence of variables, which leads to the so-called apparent regression. For this purpose, the extended ADF test for Hungary was applied. Table 3 presents detailed results of the ADF test.

Table 2. *The matrix of correlation coefficients for individual variables and countries*

Variable	BERD_CP	GERD_CP	GDE_RD	HEE_RD	T_RD_P	NTPF	NP_AF	GDP_PC	GDP_CP	GDP_NC
Hungary (HUN)										
BERD_CP	1.00									
GERD_CP	0.99	1.00								
GDE_RD	1.00	0.99	1.00							
HEE_RD	0.55	0.61	0.60	1.00						
T_RD_P	0.97	0.98	0.98	0.69	1.00					
NTPF	-0.70	-0.67	-0.71	-0.46	-0.66	1.00				
NP_AF	0.67	0.62	0.66	0.38	0.61	-0.47	1.00			
GDP_PC	0.98	0.97	0.98	0.53	0.95	-0.68	0.66	1.00		

GDP_CP	0.98	0.96	0.98	0.52	0.94	-0.69	0.67	1.00	1.00	
GDP_NC	0.97	0.96	0.96	0.49	0.93	-0.62	0.63	0.99	0.99	0.96
Netherlands (NLD)										
BERD_CP	1.00									
GERD_CP	0.98	1.00								
GDE_RD	0.94	0.99	1.00							
HEE_RD	0.69	0.81	0.88	1.00						
T_RD_P	0.97	0.99	0.97	0.78	1.00					
NTPF	-0.22	-0.34	-0.45	-0.71	-0.32	1.00				
NP_AF	0.10	0.08	0.06	-0.07	0.09	0.02	1.00			
GDP_PC	0.85	0.91	0.96	0.94	0.88	-0.63	0.04	1.00		
GDP_CP	0.84	0.91	0.96	0.95	0.89	-0.62	0.04	1.00	1.00	
GDP_NC	0.83	0.90	0.95	0.95	0.86	-0.66	0.03	1.00	1.00	1.00
Poland (POL)										
BERD_CP	1.00									
GERD_CP	0.96	1.00								
GDE_RD	0.96	1.00	1.00							
HEE_RD	0.95	0.99	0.99	1.00						
T_RD_P	0.97	0.94	0.94	0.93	1.00					
NTPF	0.86	0.94	0.94	0.95	0.84	1.00				
NP_AF	0.71	0.86	0.85	0.82	0.65	0.85	1.00			
GDP_PC	0.93	0.98	0.99	0.98	0.89	0.96	0.88	1.00		
GDP_CP	0.91	0.98	0.98	0.98	0.87	0.96	0.89	1.00	1.00	
GDP_NC	0.90	0.97	0.98	0.98	0.86	0.95	0.89	1.00	1.00	1.00
Sweden (SWD)										
BERD_CP	1.00									
GERD_CP	0.93	1.00								
GDE_RD	0.79	0.96	1.00							
HEE_RD	0.53	0.80	0.93	1.00						
T_RD_P	0.78	0.93	0.93	0.87	1.00					
NTPF	0.10	-0.22	-0.43	-0.66	-0.30	1.00				
NP_AF	0.60	0.78	0.84	0.80	0.79	-0.30	1.00			
GDP_PC	0.67	0.89	0.98	0.97	0.90	-0.52	0.88	1.00		
GDP_CP	0.68	0.90	0.98	0.97	0.91	-0.52	0.86	1.00	1.00	
GDP_NC	0.71	0.92	0.98	0.96	0.93	-0.48	0.84	0.99	1.00	1.00

Source: *Own study on the basis of the OECD database.*

Table 3. *The ADF test for checking the unit root of the analyzed variables - Hungary (2004-2018)*

Variable	ADF test for variable (p value)	ADF test over first differences (p value)	Conclusion
l_HUN_GDP_CP	0.9339	0.06159	I(2)
l_HUN_GDP_NC	0.9845	0.18490	I(2)
l_HUN_GDP_PC	0.9771	0.01298	I(1)
l_HUN_GDE_RD	0.4103	0.04806	I(1)
l_HUN_GERD_CP	0.9346	0.01180	I(1)
l_HUN_HEE_RD	0.2430	0.06022	I(2)
l_HUN_NP_AF	0.9736	0.01471	I(1)
l_HUN_NTPF	0.1128	0.00023	I(1)
l_HUN_T_RD_P	0.8786	0.00686	I(1)

Source: *Authors' calculations.*

The results obtained confirm that all analyzed time series are non-stationary (α=0,05). Some of the time series for first differences are stationary, which would give rise to the inference that the variables are integrated of degree I (1). The exceptions were the three variables analyzed l_HUN_GDP_CP, l_HUN_HEE_RD, l_HUN_GDP_NC, although, for the first two, the p-value slightly exceeds 0.06, for p = 5%, it can be concluded that they are integrated of degree II (2).

This test suggests that in further research, stationarity tests for all analyzed variables and countries should be performed in the search for interdependence. In the case of I(1) integrated series, one should use the cointegration calculus and determine the scale of interdependence and answer whether it is long- or short-run (Granger and Engle, 1987; Granger 1991; Johansen, 1988; Myszczyszyn 2020). Such an analysis will allow us to answer whether there are correlations between variables characterizing economic growth and development and data describing the level of innovativeness, as suggested by the obtained correlation coefficients.

4. Conclusion

The literature study and research results indicate that there is a mutual relationship between innovativeness and economic growth. By juxtaposing two countries that are among the EU innovation leaders with two countries which innovation level is still relatively low, it is possible to identify the impact of the catch-up effect observed in the post-communist countries of Central and Eastern Europe since the beginning of the transition, especially those incorporated into the structures of the European Union (Kondratiuk-Nierodzińska, 2016; Papava, 2018).

Over the 2004-2018 period, all innovativeness indices selected for the study grew much more dynamically in Poland and Hungary, i.e., the countries from Central and Eastern Europe which were "new" to the EU. This could mean that the countries which joined the EU in 2004 have started to catch up in this area with countries characterized by a higher degree of innovativeness. However, there is still a significant difference in this respect that should influence innovation policy directions in these Member States. This is an essential element for future action if countries such as Poland and Hungary wish to maintain above-average economic growth rates in the European Union and narrow the innovativeness gap with other members of the Community. This is extremely important given the challenges faced by EU countries due to economic, technological, social, environmental, and demographic changes. The example of countries such as the Netherlands and Sweden shows that innovativeness is an element that generates GDP growth in highly developed economies. Currently, the economies of Poland and Hungary are still lagging the European leaders in this respect, although an increase in R&D expenditures can be observed.

The obtained research results are also the basis for further considerations in the scope of the examined problem and may be used to construct econometric models, including autoregressive modeling. By the view presented in the literature, the construction of

such models should be preceded by studying the characteristics of the time series (they make it possible to learn the properties of the modeled time series) and then by studying their stationarity. Thanks to the conducted tests, it was possible to show that time series representing innovativeness and economic growth factors are non-stationary, which is a point for extending the analyses. Thus, based on the results of the conducted analysis, it will be possible to establish causality in the Granger sense further and apply models of the VAR and VECM types.

References:

Agenor, P., Neanidis, K.C. 2015. Innovation, public capital, and growth. Journal of Macroeconomics, 44(3), 252-275.

Aghion, P., Bloom, N., Blundell, R., Griffith, R., Howitt, P. 2005. Competition and Innovation: An Inverted-U Relationship. Oxford Journals. The Quarterly Journal of Economics, 120(2), 701-728.

Aghion, P., Boustan, L., Hoxby, C., Vandebussche, J. 2009. The Causal Impact of Education on Economic Growth: Evidence from U.S., Harvard University.

Aghion, P., Howitt, P. 1992. A Model of Growth through Creative Destruction. Econometrica, 60(2), 323-351.

Aghion, P., Howitt, P. 2009. The economics of growth. Cambridge: MIT Press.

Barro, R.J. 1991. Economic Growth in a Cross Section of Countries. The Quarterly Journal of Economics, 106(2), 407-443. DOI: 10.2307/2937943.

Ciborowski, R.W., Skrodzka, I. 2019. International Technology Transfer, Innovation and Economic Development of European Union Countries in 2008-2017. European Research Studies Journal, 22, 3, 384-404.

Ciborowski, R.W., Skrodzka, I. 2020. International technology transfer and innovative changes adjustment in EU. Empirical Economics, 59, 1351-1371. DOI: 10.1007 /s00181-019-01683-8.

Czarnitzki, D., Toivanen, O. 2013. Innovation Policy and Economic Growth, European Commission-Fellowship initiative The future EMU. European Economy, Economic Papers 482, 2-40. DOI: 10.2765/42480.

de Haan, J., Sturm, J.E. 2000. On the relationship between economic freedom and economic growth. European Journal of Political Economy, 16, 215-241.

European Commission. 2019. The European Green Deal. COM (2019) 640 Final. Retrieved from: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2019%3A640%3AFIN.

European Union. 2020. European Innovation Scoreboard 2020. Luxembourg. Retrieved from: https://ec.europa.eu/growth/industry/policy/innovation/scoreboards_en.

Furman, J., Porter, M.E., Stern, S. 2002. The determinants of national innovative capacity. Research Policy, 31, 899-933.

Granger C.W.J., Engle R.F. 1987. Co-Integration and Error Correction: Representation, Estimation, and Testing. Econometrica, 55(2), 251-276.

Granger, C.W.J. 1991. Developments in the study of cointegrated economic variables. In: Engle, R.F., Granger, C.W.J., Long-Run Economic Relationship, Readings in Cointegration. Oxford, Oxford University Press.

Griliches, Z. 1992. The Search for R&D Spillovers. Scandinavian Journal of Economics, 94, 29-47. DOI: 10.2307/3440244.

Griliches, Z. 1998. R&D and Productivity: The Econometric Evidence. National Bureau of Economic Research.

Grossman, G.M., Helpman, E. 1991. Innovation and growth in the global economy. Cambridge: MIT Press.

Grossman, G.M., Helpman, E. 1994. Endogenous Innovation in the Theory of Growth. Journal of Economic Perspectives, 8(1), 23-44.

Grossmann, V. 2009. Entrepreneurial innovation and economic growth. Journal of Macroeconomics, 31(4), 602-613. DOI: 10.1016/j.jmacro.2008.12.008.

Hassan, I., Tucci, C.L. 2010. The innovation-economic growth nexus: Global evidence. Research Policy, 39(10), 1264-1276. DOI: 10.1016/j.respol.2010.07.005.

Johansen, S. 1988. Statistical Analysis of Cointegration Vectors. Journal of Economic Dynamics and Control, 12(3), 231-254. DOI: 10.1016/0165-1889(88)90041-3.

King, R., Levine, R. 1993. Finance, entrepreneurship, and economic growth: Theory and evidence. Journal of Monetary Economics, 32(3), 513-542. DOI: 10.1016/ 0304-3932(93)90028-E.

Kondratiuk-Nierodzińska, M. 2016. Innovation Capabilities in EU countries: have Central and Eastern European countries been catching up? Journal of Business Economics and Management, 17(5), 765-779. DOI: 10.3846/16111699.2015.1114016.

Main Science and Technology Indicators. 2021. Retrieved from: https://stats.oecd.org/.

Mankiw, N.G., Romer, D., Weil, D.N. 1992. A Contribution to the Empirics of Economic Growth. The Quarterly Journal of Economics, 107(2), 407-437. DOI: 10.2307/2118477.

Mattalia, C. 2012. Human capital accumulation in R&D based growth models. Economic Modelling, 29(3), 601-609. DOI: 10.1016/j.econmod.2011.12.018.

Minniti, A., Venturini, F. 2013. R&D Policy and Schumpeterian Growth: Theory and Evidence, University of Bologna, Working Paper 945, 1-43.

Myszczyszyn, J. 2020. The Long-run Relationships between Number of Patents and Economic Growth. European Research Studies Journal, 23(3), 548-563.

Nadiri, M.I. 1993. Innovations and Technological Spillovers, Working Paper 4423. National Bureau of Economic Research, Cambridge.

Neuhaus, M. 2006. The impact of FDI on Economic Growth: an Analysis for the Transition. Countries of Central and Eastern Europe. Contribution to Economics. DOI: 10.1007/3-7908-1735-X-1.

Papava, V. 2018. Catching Up and Catch-Up Effect: Economic Growth in Post-Communist Europe (Lessons from the European Union and the Eastern Partnership States). European Journal of Economic Studies, 7(2), 109-125. DOI: 10.13187/es.2018.7.109.

Park, W.G. 1995. International R&D spillovers and OECD economic growth. Economic Inquiry, 33(4), 571-591. DOI: 10.1111/j.1465-7295.1995.tb01882.x.

Pece, A.M., Simona, O., Salisteanu, F. 2015. Innovation and Economic Growth: An Empirical Analysis for CEE Countries. Procedia Economics and Finance, 26, 461-467. DOI: 10.1016/S2212-5671(15)00874-6.

Pessoa, A. 2007. Innovation and Economic Growth: What is the actual importance of R&D? University of Porto, FEP Working Papers, 254, 1-17.

Petrariu, I.R., Bumbac, R., Ciobanu, R. 2013. Innovation: a path to competitiveness and economic growth. The case of CEE countries. Theoretical and Applied Economics, 5(582), 15-26.

Pop Silaghi, M.I., Alexa, D., Jude, C., Litan, C. 2014. Do business and public sector research and development expenditures contribute to economic growth in Central and Eastern European Countries? A dynamic panel estimation. Economic Modelling, 36(C), 108-119. DOI: 10.1016/j.econmod.2013.08.035.

Rodionov, D.G., Kudryavtseva, T.J., Skhvediani, A.E. 2018. Human Development and Income Inequality as Factors of Regional Economic Growth. European Research Studies Journal 21(2), 323-337. DOI: 10.35808/ersj/1259.

Romer, P.M. 1986. Increasing Returns and Long Run Growth. Journal of Political Economy, 94(5), 1002-1037.

Samimi, A.J., Alerasoul, S.M. 2009. R&D and Economic Growth: New Evidence from Some Developing Countries. Australian Journal of Basic and Applied Sciences, 3(4), 3464-3469.

Schumpeter, J.A. 1912. The Theory of the Economic Development: An Inquiry into Profits, Capital, Credit, Interest and Business Cycle. Cambridge: Harvard Press.

Slepov, V.A., Burlachkov, V.K., Danko, T.P., Kosov M.E., Volkov, I.I., Grishina, O.A., Sekerin, V.D. 2017. The Country's Economic Growth Models and the Potential for Budgetary, Monetary and Private Financing of Gross Domestic Product Growth. European Research Studies Journal, 20(4A), 488-500. DOI: 10.35808/ersj/849.

Solow, R. 1956. A Contribution to the Theory of Economic Growth. The Quarterly Journal of Economics, 7(1), 65-94.

Ulku, H. 2004. R&D, Innovation, and Economic Growth: An Empirical Analysis. International Monetary Fund Working Papers, 4(185), 2-35.

Westmore, B. 2013. R&D, Pateting and Growth: The Role of Public Policy. OECD Economics Department Working Papers, 1047, OECD Publishing, 2-48.

Wong, K.P., Ho, Y.P., Autio, E. 2005. Entrepreneurship. Innovation and Economic Growth: Evidence from GEM data, Small Business Economics, 24(3), 335-350.