

Education as a factor influencing the economic growth of the V4 countries

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Abstract: *The phenomenon of the Fourth Industrial Revolution fundamentally affects the essence of the functioning of industry, trade and many other parts of the economy of developed countries. New and developing disciplines will need workers with a high-quality education matching the needs and demands of technological development. In order to evaluate education as a determinant of economic growth, multivariate regression models were created for each of the V4 countries separately. In this work, it was examined whether the variables related to primary, secondary and especially tertiary education affect economic growth. Data for V4 countries come from 2000-2020. From the estimated models, it can be concluded that in all the countries selected there is a positive impact of tertiary education on the economic situation of the country.*

Keywords: education, Industry 4.0, GDP per capita, economic growth, Visegrad Group

JEL Codes: H52, I25

1. Introduction

The technological changes currently coming to market are changing society and our way of life, creating the concept of the Fourth Industrial Revolution. Every industrial revolution is reflected in a significant factor in people's lives. The Fourth Industrial Revolution, or Industry 4.0, which is the stage we are at today, is bringing with it revolutionary changes in production, but also in the fields of economics, the labour market and education. Industry 4.0 has the greatest impact on the position in the labour market, the training of potential and existing employees, but also on production.

The Europe 2020 strategy set the boundaries in the various areas to be achieved by the Member States at the end of 2020. One of them is the goal of research and development. Specifically, there is a target set for each EU country to spend at least 3% of its GDP on R&D in 2020. Mudronja et al. (2019) assume that R&D is considered by many theories to be a driving force for long-term economic growth and, therefore, it requires investments. Thanks to the implementation of new production processes, work organization will bring continuity and interconnectedness to professions and work processes.

As a result of the changes brought about by the industrial revolution, the education of the population plays an important role. It is much better to apply more complex technological procedures to a population with a large proportion of those with tertiary education than to populations where a large part has only primary education.

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In his work, White (2014) focused on the importance of education in the field of STEM (science, technology, engineering and mathematics). In his work, the author emphasizes the fact that in the case of quality education in the field of STEM, students are interested in science, technology, engineering and mathematics. Subsequently, these students choose a career in this area. These people then become scientists who participate in research activities and thus become the bearers of economic growth.

In 2015, Dragoescu (2015) also dealt with education as a determinant of economic growth. Using Romanian data, she examined and analysed longitudinal data from 1980 to 2013. In them, she found that there is a connection between higher education and economic growth. Stankic et al. (2018) have a similar view on education in their article. According to their research, ICT and education are important determinants of economic and overall social development.

Undoubtedly, every state wants to increase its economic level. In the context of Industry 4.0. technological development, increasing demands are placed on the technical knowledge and skills of employees. Therefore, education can be considered one of the main factors that could bring about an improvement in the economic level of countries. Tertiary education in the V4 countries is largely financed from the state budget. If raising the level of education did not bring increased labour productivity and thus economic growth, the financing of education from the state budget would be an item that could potentially be better used in other sectors.

The aim of this article is to evaluate whether the level of tertiary education affects economic growth in the V4 countries. This relationship will be investigated using multidimensional regression. The specific researched factors that could affect the size of the GDP of the V4 countries will be selected based on research in the theoretical basis. Thanks to the technical revolution of Industry 4.0., it must exceed the knowledge requirements of job seekers, it will give priority to examining the impact of education on the aforementioned economic levels of countries.

Two hypotheses were established for the econometric analysis.

- The level of tertiary education significantly affects the size of GDP in individual countries.
- The V4 countries have a similar structure of educational factors influencing the size of the countries' GDP.

2. Theoretical background

Liao et al. (2018) in their work dealt with the Fourth Industrial Revolution, which is usually referred to as Industry 4.0. They assumed that research and new technologies were closely linked to the ongoing industrial revolution and that this revolution would have a positive effect on economic development. It has been shown that science, education, human capital and training are the biggest contributors to creating good conditions for the Fourth Industrial Revolution, which has a further impact on GDP growth, the determinant of economic growth.

Gleason et al. (2018) addressed the issue of the need to increase the skills of workers as a condition for the introduction of Industry 4.0 in practice. They mention the need to work to create a digitally literate and technologically competitive society, especially with the help of professionals who will be highly-educated. According to Gleason et al. (2018), this also influences whether universities have partnerships in a world where students can complete exchange programs and gain greater insight. In their work, the authors mainly examined the issue of Singapore's economic growth associated with Industry 4.0. The authors note that Singapore is currently investing a lot of resources in tertiary education. It has even become one of the main government tools for economic development. According to the authors, the lifelong education of existing workers is also an important element for the successful implementation of the innovations associated with the Fourth Industrial Revolution.

Jung (2020) has dealt with the Fourth Industrial Revolution and the associated knowledge economy in the conditions of South Korea. This was based on the idea that knowledge is the main driver

of economic growth in all world economies and, at the same time, it is becoming a new comparative advantage. It was found that the strengths that create a suitable environment for the knowledge economy are a skilled workforce with a university degree, and higher R&D spending. Specific private companies and their focus, located in the given region, also have a great influence on the development of Industry 4.0.

Langdon (2011), the U.S. Department of Commerce, Economics and Statistics Administration published an article on the fields that will be needed for the labour market in the future. The STEM disciplines, which are science, technology, engineering and mathematics, were identified as key elements. According to the article, it is precisely these fields that have the greatest impact on competitiveness and innovation and the development of any economy. It is these factors that are subsequently an important determinant of economic growth. The article analysed the US labour market, which was divided into STEM and non-STEM workers. STEM workers are more likely to have a university degree and their incomes are on average 26% higher. The market analysis came to the conclusion that it is expected that STEM workers will be increasingly in demand in the future. This will be associated with a high increase in job positions in these fields. And therefore there will be an increased interest in education in this area.

In their study, Kennedy and Odell (2014) also addressed the importance of STEM workers in the labour market in increasing the competitiveness of economies. In their work, they examined in particular the process of teaching the given disciplines and the connection between higher education and the workforce. The conclusion of their work was that economic development not only requires workers educated in one of the STEM fields. According to the authors, it is necessary for students to gain a wider perspective and to choose multidisciplinary studies or enrol in subjects in other fields at schools. This can make STEM more interesting for a larger group of people, as even those students who study sciences other than STEM can learn certain information from STEM disciplines and thus contribute to the development of their field. Kennedy and Odell (2014) argue that STEM disciplines encourage students to think critically and use technology to find solutions to their questions.

In her work, Theodoropoulou (2019) also addressed the skills required in the market. She mentioned several sectors that seem interesting in the future, such as IT, research and development, marketing, healthcare and legal services. All these professions have a medium or high qualification as a requirement. Most of the "professions of the future" will require specific skills and therefore an emphasis on knowledge. She found that there is a correlation between the number of tertiary education graduates and added value in research and development. Therefore, following the EU strategy, he argues that the quality rather than the quantity of tertiary education needs to be improved. Furthermore, the work deals with the level of key competencies (reading, mathematics and general knowledge) in basic education. However, it also evaluates the quality of teaching in schools using the length of study and the subject matter. He sees the need to eliminate early school leaving and combatting social inequalities as important factors in raising qualifications.

Mercan and Sezer (2014) dealt with the issue of the influence of education on economic growth. They assumed that education has a significant impact on the development of countries through a positive effect on increasing human capital. This seems to be a good economic tool for combatting unemployment and poverty. In the Turkish environment, they modelled GDP depending on the size of education expenditure. Through a regression analysis of these time series, it was found that education expenditure has a significant positive statistical effect on GDP. In their work, Mercan and Sezer (2014) further note that GDP growth is used as the factor of economic growth according to economic theories. Therefore, it has been shown that increasing spending on education, especially tertiary education, has a major impact on the growth of the national economy.

Similarly, Holland et al. (2013) based their study on the assumption that there is a positive relationship between education levels and GDP growth rates. The authors managed to demonstrate the important role of a university-educated workforce in economic growth and increasing competitiveness. Specifically, based on their research, they found that a 1% increase in the share of the workforce with a university degree increases the level of long-term productivity by up to 0.5%.

Danacica and Belascu (2010) examined the connection between higher education and economic growth, specifically in the conditions of Romania. The relationship was examined on the basis of the VAR model, which was constructed in such a way that, as in other works of a similar type, GDP became the determinant of economic growth. One of the explanatory factors for GDP modelling was the level of higher education. Based on the model, the authors demonstrated Granger's causality between variables, and thus the fact that GDP is affected by the level of higher education.

In contrast, Freimane and Balina (2016) assessed in their article whether research and development have an impact on economic growth. In the EU, they modelled GDP in individual countries converted into employees. Domestic and foreign investment, expenditure on research and development, and the recalculated number of tertiary educated people in the labour market were used as explanatory variables. Both point out that the bearers of human capital that have had an impact on research and development are primarily people with a completed tertiary education. They used all these variables, both exploratory and explanatory, in logarithmic form, as the percentage changes seemed to express reality better than the unit changes. In their work, Freime and Balina used the objectives of the Europe 2020 strategy, which set out the share of R&D spending that individual Member States want to achieve by 2020. The countries with the highest share of R&D to GDP are the Scandinavian countries (Sweden and Finland) and then the countries of western Europe, namely Denmark, Germany and Austria. By contrast, countries such as Cyprus, Romania and Bulgaria were the worst off in 2013. Unfortunately, according to the authors, the results of the research by Freiman and Balina (2013) were negatively affected by significant heterogeneity between Member States. Nevertheless, R&D expenditure was found to have a positive statistical effect on the size of real GDP. Following the division of Member States into more homogeneous groups, it was found that countries with R&D expenditure of less than 1% are the R&D parts of the economy that should be taken into account in order to allow the national economy to grow.

Fernald and Jones (2014) also looked at the future of economic growth in the context of education and research and development. According to the results of their work, the trend that has been observed so far will slow down. In particular, the concentration of research and development in the field of artificial intelligence, which could replace some workers in the future, is a new start for the rapid growth of technology. In addition, Fernald and Jones note that China and India will become strong new players in research and development.

In contrast, Mudronja et al. (2019) examined the relationship between economic growth and investment in research. In their work, they focused mainly on the growth of the regions. They explained regional growth (expressed as GDP per capita) through R&D investment and also examined variables such as unemployment and population change. The results of their work have shown that regions that invest more resources in research and development also show higher economic growth and at the same time do not tend to reach a saturation point where economic growth stops completely. At the end of their work Mudronja et al. (2019) also note that innovation is a key source of competitive advantage. Therefore, R&D regions need to focus on the latest technologies and trends.

In their work, Sokolov-Mladenovic et al. (2016), similar to other authors, found that the source of competitive advantage within individual economies is mainly knowledge and technology. They rely on the fact that in the new theory of growth, the study of knowledge is a key determinant for economic growth. The authors conducted their research on the basis of a regression panel analysis for the EU28 countries. They chose the growth rate of real GDP as a dependent variable; the independent variable was primarily the share of R&D expenditure to GDP. In addition, control explanatory variables that should have an impact on real GDP growth, such as gross fixed capital formation, the share of government final consumption expenditure and fertility rates, were included in the model. Based on this linear model, they managed to prove that with a 1% increase in R&D expenditure, real GDP will increase by 2.27%.

The impact of research and development on economic growth and productivity was investigated by Blanco et al. (2015). Their work is based on the values observed in individual US states for the years 1963-2007. Using an econometric model, they examined the relationship between investment in

research and development and productivity in a country's economy. They managed to statistically demonstrate that research and development has a long-term positive impact on economic growth. Specifically, the model shows that increasing R&D spending by USD 1 increases GDP by almost USD 5.

Bayarcelik and Tasel (2012), who dealt with the situation in Turkey, viewed the impact of research on economic development. These authors believed that economic growth is mainly due to the presence of companies in the market that specialize in the newest production methods and processes. During the analysis, they found that it is appropriate to deal with specific companies that carry patents for new technologies. Bayarcelik and Tasel (2012) modelled GDP as a function, which is explained by the number of employees in research and development, the number of patents in a given company and R&D expenditure. All variables in the model were logarithmized, as the percentage increments turned out to be more telling under the given conditions. Based on their research, it was found, as in other studies, that there is a positive relationship between the number of R&D employees and GDP growth, as well as between R&D expenditure and GDP growth. At the same time, however, it surprisingly was also shown that there is a significant, but negative, relationship between the number of patents and GDP growth.

Similar research was conducted in the environment of the BRICS countries (Brazil, Russia, India, China and South Africa) by two scientists, Wang and Zhang (2020). They based their work on the assumption that it is science and technology that bring socio-economic development. In their work, the authors did not only consider economic growth independently, but also dealt with the environment, which may be burdened mainly by CO₂ emissions due to increasing technologies. Therefore, they tried to find a relationship that would reflect that not only research and development helps economic growth, but also the creation of new technologies that save the environment. This was confirmed by the authors, as a positive impact between research and development and the reduction of CO₂ emissions has been demonstrated. This fact had the most significant impact in Russia and China. In conclusion, it is Wang and Zhang (2020) who mention that research and development should focus primarily on investment in the development of renewable energy in order to avoid environmental pollution due to economic development.

The relationship between research and development and economic growth has also been investigated by Mudronja et al. (2019); they use the theory of endogenous growth in their work for research on economic growth. They primarily focus on an analysis of the impact of investments in research and development through panel analysis of data in selected EU countries. The logarithm of GDP per capita in a given regional unit was chosen as the explained variable. This variable is explained in the model using the first-order autoregressive variable, the size of investment in research and development, unemployment in the region, population changes in the region, trade openness of the region and transport infrastructure. Based on their research, it was found that there is a positive relationship between investment in research and development and GDP growth in the area. They further emphasize that individual regions should strive to develop the social, cultural and institutional environment so as to set suitable conditions for innovation processes and thus increase their competitiveness.

In his article, Jakopin (2020) dealt with economic growth and the impact of structural changes. He sees the importance of economic growth as having a positive effect on changes in the labor market.

Maradana et al. (2017) took a different view on this issue. They addressed the question of whether innovation contributes to economic growth. In their work, they tested the causality between innovation and economic growth in the environment of European countries. To do this, they created several econometric models. In a sample of 19 European countries, including the Czech Republic, it was proved that there is a mutual Granger causality between innovation and economic growth. As this is a mutual causality, the authors point out that it is necessary to focus not only on supporting innovation in order for economic growth to happen, but also on supporting economic growth in order for innovation to take place. At the end of the article, the authors Maradana et al. (2017) point out that it is also necessary to focus on economic policies that increase economic growth. In particular, by establishing a suitable and

stable environment for companies, so that even private companies are willing to invest more in research and development and thus bring innovation to the economy. Examples of such measures may be various tax measures or the provision of subsidies and grants.

3. Data and methodology

The data for this work were obtained from the publicly accessible databases of official organizations. Specifically, these are organizations such as Eurostat, the World Bank and the OECD. All selected time series were for the period 2000—2020.

A country's economic growth was measured using real GDP per capita in euros. The following variables were selected as potential factors influencing a country's economic growth. The selection of variables was inspired by the studies in Table 1. Specifically, it was government expenditure per student on tertiary education as % of GDP per capita, expenditure on tertiary education as % of government expenditure on education, gross domestic spending on R&D as % of GDP, indicators of population by education as a percentage of the total population separately for primary, secondary and tertiary education and, last but not least, indicators of the unemployment rates of young people not in education who have achieved a given level of education as a percentage of the total population separately for primary, secondary and tertiary education.

Table 1: Choice of variables for multidimensional regression model

Indicator	Authors
GDP per capita	Mundronja et al. (2019), Danacica and Belascu (2010)
Government expenditure per student on tertiary education	Freimane a Balina (2016)
Expenditure on tertiary education	Mercan a Sezer (2014)
Gross domestic spending on R&D	Jung (2020)
Population by education of primary/secondary/tertiary level	Freimane a Balina (2016), Gleason et al. (2018), Holland et al. (2013)
Unemployment rates of young people not in education	Mundronja et al. (2019)

The finding of statistically significant factors was performed using a multidimensional regression analysis of time series, similar to the article in Zámková, Blašková (2013). A t-test was used to test the statistical significance of the parameters.

Multicollinearity between explanatory variables was verified using VIF values. The assumption of the correct model specification was verified using the LM test. The White test was used to test the heteroskedasticity of the residue. The Chi-Square test was used to verify the assumption of a normal residue distribution. The absence of autocorrelation in residues was checked using a residue correlogram. Last but not least, attention was always paid to apparent dependence in time series. Because economic time series are usually non-stationary, the cointegration of time series has always been verified by means of the ADF and KPSS test and the above-mentioned correlogram of residues. The quality of the model was evaluated using the Theil coefficient.

4. Results

4.1. Model estimates

Based on the ADF test and the KPSS test, it was found that the selected time series are non-stationary. In order to verify the concept of cointegration, it was necessary to proceed to the estimation of the models themselves. To answer the research question, four models were created, one for each of the V4 countries. Based on the graphical analysis of time series, a linear functional form was chosen and individual variables according to VIF values did not show multicollinearity. The final models were created using descending elimination. All models were subjected to tests of classical assumptions. Table 2 shows the p-values for the tests used for the most frequently violated assumptions.

Table 2: P-value of tests of econometric assumptions

	CZ	HU	PL	SK
LM test	0.010	0.402	0.036	0.014
White test	0.217	0.389	0.582	0.196
Breusch-Pagan test	0.927	0.796	0.505	0.081
Chi-Square test	0.755	0.621	0.368	0.313

A slight discrepancy with the specification was identified within the models. From the results of the analysis and graphical representation of the data, it was found that there are remote observations in the models. Violation of the assumption of correct specification was slight, so the models were subjected to further tests. In the tests of heteroscedasticity and normality, the p-values reach values higher than 0.05, so none of these assumptions were violated for all models of the V4 countries. If we look at the graphs of autocorrelation functions (see Figure 1), the problem of autocorrelations cannot be identified from them.

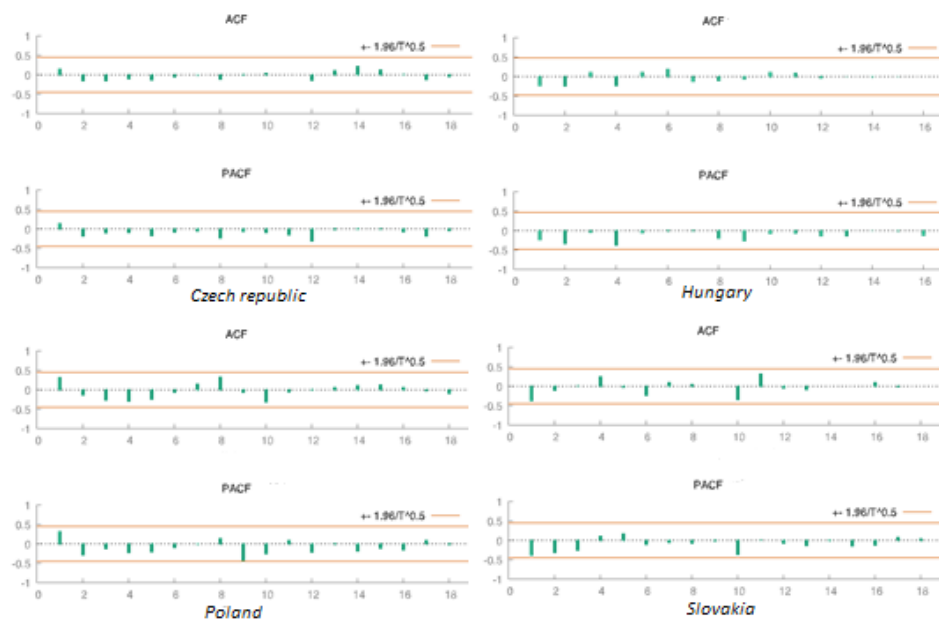


Figure 1: ACF and PACF functions for V4 countries

The time series that were used for modelling were non-stationary. Therefore, it was necessary to verify whether the residues of the resulting models are stationary. This was done on the basis of graphical

evaluation of the correlograms of residues of individual models and on the basis of p-values of ADF tests and KPSS. The correlograms of the residues and the results of the stationarity tests are shown in Figure 1.

Table 3: P-value for results of stationarity for residues

	p-value			
	CZ	HU	PL	SK
ADF test	0.002	<0.001	0.013	0.003
KPSS test	> .10	> .10	> .10	> .10

Based on the analysis of correlograms, the time series of residues do not show problems with non-stationarity. This conclusion is also supported by the test results from Table 3. The estimated models can be considered high quality, as evidenced by the value of Theil's coefficient of inequality. Its values for individual models of the V4 countries are given in the table below (see Table 4).

Table 4: Theil's coefficient of inequality

	CZ	HU	PL	SK
Theil U	0.380	0.425	0.290	0.388

The values of Theil's coefficient of inequality coefficient did not exceed 0.425, which indicates sufficient quality and suitability of the assembled models. The values given in Table 4 show that the lowest value of Theil's coefficient is in the case of Poland, which indicates the best quality of this model. Furthermore, the Czech Republic and Slovakia show very similar values. The highest value of the coefficient and with it the highest discrepancy can be observed in the case of Hungary.

4.2. Economic interpretation of models and discussion

According to the created models, it can be stated that education significantly affects GDP. The components of education that affect GDP vary from country to country, but despite this, all the models are largely similar. In all four models, for example, they remained important indicators of the number of tertiary educated people. Other explanatory variables vary across the models, due to differences at the V4 level. The resulting models are listed below.

$$GDP_{CZ} = -81573.7 + 1235.21 SEC_{CZ} + 888.678 TER_{CZ} - 259.872 U_SEC_{CZ} - 368.840 U_TER_{CZ}$$

$$GDP_{HU} = -11667.4 + 369.181 SEC_{HU} + 207.194 TER_{HU} - 125.659 U_SEC_{HU} - 62.889 EXP_S_{HU}$$

$$GDP_{PL} = 5577.63 + 201.769 TER_{PL} - 159.951 U_TER_{PL} + 1529.26 RD_{PL}$$

$$GDP_{SK} = -23923.7 + 430.376 SEC_{SK} + 571.035 TER_{SK} - 177.858 U_SEC_{SK} + 150.705 U_TER_{SK}$$

where GDP is time series of real GDP per capita;

SEC is time series of population by education for secondary education;

TER is time series of population by education for tertiary education;

U_SEC is time series of unemployment rates of young people not in education for secondary education;

U_TER is time series of unemployment rates of young people not in education for tertiary education;

EXP_S is time series of government expenditure per student;

RD is time series of gross domestic spending on R&D.

Based on the comparison of models, we can state that the variables included in the models for the Czech Republic and Slovakia are identical. The GDP of both of these countries is influenced by the

share of secondary and tertiary educated people and at the same time by the percentage of unemployment of the population whose highest level of education attained is secondary or tertiary. This similarity is probably explained historically, since these countries once formed one whole and still have very similar social and economic environments. A very similar model was created for Hungary. This model does not include a variable related to the unemployment of the population with the highest tertiary education attainment. On the contrary, there is an indicator of expenditure on tertiary students. The most different model from the others is the model for Poland, in which there are no variables related to secondary education, but on the contrary, GDP is affected by the size of R&D expenditure.

In all models, it is possible to observe that tertiary education affects GDP in all monitored countries. Tertiary education has the greatest impact on GDP in the Czech Republic, where each increase in the number of tertiary educated by 1% will raise GDP per capita by EUR 888.678 *ceteris paribus*. In Slovakia, due to a 1% increase in the share of tertiary educated people under otherwise unchanged conditions, GDP per capita increases by EUR 571.035, in Hungary it is an increase of EUR 207.194 and in Poland by EUR 201.769. Dragoescu (2015) came to a similar conclusion in his work, who also demonstrated the relationship between tertiary education and economic growth.

The size of GDP per capita in the Czech Republic, Hungary and Slovakia is influenced not only by the share of tertiary educated people, but also by the share of secondary educated people. The indicator of the share of tertiary educated people in the Czech Republic has the greatest influence on GDP. There, an increase in the number of tertiary educated of 1% increases *ceteris paribus* GDP per capita by EUR 1235.21. In Hungary, the impact is much smaller, with an increase in the share of tertiary educated people of 1%, GDP per capita grows by EUR 369,181 *ceteris paribus*. The lowest influence of the share of tertiary educated people on GDP per capita can be observed in Slovakia. Here, *ceteris paribus*, GDP per capita increases by EUR 430.376 due to a 1% increase in the share of secondary education. However, it should be emphasized that in the Czech Republic and Hungary the impact of the share of secondary education on GDP is higher than the impact of the share of tertiary education. This may be due to the relatively small number of tertiary educated people in these countries. While the share of tertiary educated people according to Eurostat was on average 29.6% in the EU28 in 2019, but in the Czech Republic it was only 21.6% and in Hungary it was 22.5%. However, due to the relatively small number of tertiary educated people, the Czech Republic and Hungary have a larger proportion of the population whose highest level of education is secondary. In 2019, according to Eurostat, 45.6% were secondary educated in the EU28, 66.1% in the Czech Republic and 57.6% in Hungary. According to Loening (2005), the cause of economic growth is education, both primary, secondary and tertiary. In his work, he emphasized that secondary education significantly affects economic growth, especially in countries where the share of tertiary educated people is not so significant, as evidenced by the results described above.

In the Czech Republic, Hungary and Slovakia, GDP is also affected by the percentage of the unemployed whose highest level of education is some form of secondary education. Unlike the previous ones, this indicator has a negative effect on GDP. As Dumitrescu et al. (2009) found, unemployment is very closely related to the size of GDP, so their mutual correlation should be negative. This was also confirmed in the models mentioned above. In all countries where this time series had a significant parameter, we can observe a negative sign. The GDP of the Czech Republic is again most affected by this indicator. In the case of a single percentage increase in unemployment of the secondary educated, there is a decrease of EUR 259.872 in the Czech Republic, *ceteris paribus*. In Slovakia, in the same situation, it is a decrease of EUR 177.858, in Hungary it is a decrease of EUR 125.659.

The percentage of unemployed in the population who have completed tertiary education proved to be a significant factor in three countries. They are the Czech Republic, Poland and Slovakia. Among these countries, unemployment of the tertiary educated has the greatest negative impact on GDP, again in the Czech Republic. Here, due to the growth of unemployment among tertiary educated people, *ceteris paribus*, there is a decrease in GDP per capita by EUR 368.840. In Poland, this indicator has a lower, but still negative, effect on GDP. Here, *ceteris paribus*, with a percentage increase in unemployment in the tertiary educated population, GDP per capita decreases by EUR 159.951. The unexpected value of

the parameter has appeared in the model of Slovakia. In Slovakia, due to rising unemployment among the tertiary educated, GDP is growing. Specifically, GDP per capita grew by EUR 150.705 due to a 1% increase in the number of unemployed in tertiary education, *ceteris paribus*. The positive relationship between these variables in Slovakia can be argued in the relatively short observed period by the fact that GDP per capita increased between 2000 and 2020. At the same time, it is possible to observe sharp short-term increases in unemployment of tertiary educated people in Slovakia between 2003 - 2004, 2006 - 2012 and subsequently 2019 - 2020. In the long run, it can be assumed that, as in other V4 countries, the relationship between unemployment and GDP would be negative. At the same time, Slovakia has a systematically higher unemployment rate compared to other V4 countries. In some years, there were up to 50% more unemployed people in Slovakia with a completed tertiary level of education than in other V4 countries.

GDP in Hungary is also statistically significantly affected by the size of expenditure per tertiary student. Expenditure on tertiary students is calculated as a percentage of GDP per capita. In the case of Hungary, the growth of expenditure per tertiary student has, *ceteris paribus*, a negative effect on GDP per capita. An explanation for the negative relationship between these variables may be, for example, that expenditure as a percentage of GDP in Hungary is systematically one of the lowest in the EU. For example, in 2012, according to World Bank data, only Bulgaria reported lower expenditure on tertiary students. Therefore, it can be stated that spending on tertiary students in Hungary is insufficient to have a positive effect on economic growth. Mercan and Sezer (2014) concluded that education spending boosts economic growth by examining the situation in Turkey, which showed that increasing tertiary education spending has a significant impact on a country's economic growth. However, it should be noted that, according to the World Bank, Turkey had more than twice the expenditure of tertiary students in 2012.

The last indicator that proved to be significant in the resulting models is R&D expenditure. This parameter proved to be statistically significant only in the case of Poland. In Poland, R&D expenditure has a positive relationship with the size of GDP per capita. *Ceteris paribus*, this is a specific increase in GDP per capita of EUR 1529.6 in the event of an increase in R&D expenditure by 1% of GDP. The great importance of research and development as a determinant of economic growth has also been demonstrated by Jung (2020).

5. Conclusions

In all four V4 countries, tertiary education was found to affect GDP as a determinant of economic growth. The share of tertiary educated people was statistically significantly reflected in the model for the Czech Republic, Hungary, Poland, and Slovakia. In all countries, based on a multidimensional regression of time series, it has been shown that as the proportion of tertiary-educated people in each population grows, so does the national GDP per capita. At the same time, it was demonstrated using the example of the Czech Republic that with the growth of unemployment of the tertiary educated, the size of GDP per capita decreases.

By comparing the created models, it was shown that all V4 countries have a similar structure of factors in the field of education, which affect the size of their GDP. In particular, the size of GDP in the Czech Republic and Slovakia is determined by identical factors. This is probably due to the common history of both countries. Until 1992, these countries formed one common state. Thanks to this, a very similar social, economic, and cultural environment is set up in both countries today.

Furthermore, by using the models, it was proved that the size of GDP per capita in the Czech Republic and Slovakia is influenced by the share of secondary and tertiary educated people and at the same time by the size of unemployment of persons whose highest educational attainment is secondary and tertiary. In both countries, a positive relation was demonstrated between the share of secondary education and GDP and at the same time between the share of tertiary education and GDP.

The model for Hungary was different from the models of the Czech Republic and Slovakia by only one variable. Within Hungary, unemployment of the tertiary educated does not contribute statistically significantly to GDP per capita. On the contrary, expenditure on tertiary education students was found to affect Hungary's GDP per capita. In Hungary, the variable including the size of expenditure on tertiary education students was reflected in GDP per capita and was unexpectedly negative. This is due to its relatively low expenditure on tertiary education, which, for example, was the second lowest in the European Union in 2012, according to the World Bank. For this reason, the size of expenditure on tertiary education is insufficient and should be increased to have a positive impact.

The model of Poland differed the most from other models, where it was shown that the share of tertiary educated people has a positive effect on the size of GDP per capita, and expenditure on research and development also has a positive effect. There has been a positive correlation between R&D expenditure and GDP per capita in Poland. From this, it can be argued that increasing spending on research and development will also bring about GDP growth.

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7. References

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