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EDUCATIONAL AND INNOVATIVE ELEMENTS OF HUMAN CAPITAL AND THEIR IMPACT ON ECONOMIC GROWTH[1]

Abstract. Human capital is an important factor for economic growth and the development of socio-economic systems. However, the appropriate expression of the value of human capital, the mechanism and its impact on economic development are still under discussion. It is hypothesised that there is a relationship between human capital and economic growth. To test this hypothesis, data on the group of Visegrad (V4) countries for the period 2000–2019 was analysed. The study examines the presence of a causal link between some attributes of human capital and economic growth and the conditions, under which its positive effects can be expected based on statistical methods. It also deals with the role and the applicability of some of its characteristics to express the impact of human capital on economic growth. The model revealed a positive, statistically significant relationship between gross domestic product per capita and the innovative capacity of human capital and the qualifications of employees. The impact of tools for human capital creation and development extends over a longer period and is reduced by the simultaneous action of other labour market factors. Currently, economies are affected by the Covid-19 pandemic. Corresponding changes are also noticeable in the way work is done, with more weight on the home office. It will be interesting to examine how this transformation will affect economic growth. The changes in the position of employees and the care of companies for human capital are also a good topic for further research that can be conducted every few years.

Keywords: human capital, education, GDP per capita, research and development, economic growth, expenditure on education, ratio of students to teacher, employees in research and development, patents, V4 countries

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ИССЛЕДОВАТЕЛЬСКАЯ СТАТЬЯ

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Образовательно-инновационный аспект человеческого капитала и его влияние на экономический рост

Аннотация. Человеческий капитал — важный фактор экономического роста и развития социально-экономических систем. Однако вопросы, связанные с адекватным выражением ценности человеческого капитала и механизмами его влияния на экономическое развитие, до сих пор остаются открытыми. В статье выдвигается гипотеза о наличии взаимосвязи между человеческим капиталом и экономическим ростом. Для ее проверки проанализированы данные стран Вишеградской группы за период 2000–2019 гг. При помощи статистических методов исследована причинно-следственная связь между некоторыми аспектами человеческого капитала и экономического роста, а также условиями, обеспечивающими положительный эффект. Также проанализирована роль некоторых характеристик, используемых для выражения влияния человеческого капитала на экономический рост. Представленная в статье модель продемонстрировала наличие положительной статистически значимой связи между валовым внутренним продуктом на душу населения и показателями инновационного потенциала человеческого капитала и квалификации работников. Влияние инструментов создания и развития человеческого капитала проявляется в долгосрочном периоде и снижается из-за одновременного воздействия иных факторов рынка труда. К примеру, пандемия COVID-19 негативно повлияла на развитие экономики, что привело к соответствующим изменениям в сфере занятости, в частности к переходу на удаленную работу. Воздействие подобной трансформации на экономический рост представляет научный интерес. Изменения в карьерном продвижении сотрудников и отношении компаний к человеческому капиталу также являются перспективной темой для дальнейших исследований, которые можно проводить раз в несколько лет.

Ключевые слова: человеческий капитал, образование, ВВП на душу населения, НИОКР, экономический рост, расходы на образование, соотношение учащихся и преподавателей, занятые в НИОКР, патенты, Вишеградская четверка

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Introduction

For several decades, the economic growth has been one of the most debated areas of the economy, attracting the attention of many economists (Acemoglu, 2012). Regional differences in the performance of territorial units and in the living standards of their inhabitants are a long-term phenomenon. This phenomenon can be observed among countries, as well as among their administrative units. Every successful economy must constantly improve and pay increased attention to key areas. These can ensure sustainability and improve the country's position in a competitive environment (Širá et al., 2020). Although the size of disparities varies and, according to statistics (OECD, 2020), decreases over time, economists are looking for the cause of their existence. The reason is prosaic. The lower rate of economic growth of some regions (territorial units) with the extension of the lag period reduces the region's ability to develop independently. This puts pressure on the state and its institutions to perform social functions, more precisely on public resources, the use of which is to complement or even replace the creation of own resources. This is one of the reasons why a large number of theorists and economic practice itself are looking for the driving forces of regional growth. Many authors (Riley, 2012; Lucas, 1988; Mankiw et al., 1992; De La Fuente & Doménech, 2000; De La Fuente & Doménech, 2006) cite human capital as such a force and examine its impact on production through labour productivity (Romer, 1989; Mankiw et al., 1992). Greater inequality, on the contrary, might increase growth if highly educated people (secondary or tertiary) are much more productive; then high differences in rates of return can encourage more people to seek education. Next reason is if higher inequality promotes aggregate savings and thus capital accumulation (Cingano, 2014).

Literature Review of Human Capital and Economic Growth

In the classical theory of economic growth, labour productivity is considered to be an exogenous factor, which depends primarily on the ratio between labour and physical capital, limited by e.g. degree of technical progress. Newer theories of economic growth, developed in the early 1980s, differ from classical theory by emphasising the importance of the human factor. They see the source of long-term economic growth in intangible assets. They emphasise the importance of intellectual capital, originating in education and reflected in research, development, and innovation.

In a broader sense, economic growth can also be referred to as economic development. It is currently a frequent object of interest for many experts. First, this area is attractive for many scientists, since it has a number of unknowns. As Kuznets emphasised, economic development is very multifaceted. It is not only about the growth of aggregate production, but also about the fundamental transformation of the economy, which ranges from a sectoral structure to a demographic and geographical composition and perhaps even more importantly throughout the social and institutional structure. On this basis, a more holistic approach to economic growth is needed. Therefore, political, social and demographic elements are paramount in the growth process (Acemoglu, 2012). Peterson (2017) believes that economic growth in high-income countries will be slower in the coming period due to a slowdown in population growth there. However, given the limited resources, population growth is emerging as a problem.

The human capital is explained as a sum of the abilities and skills of the workforce used in economic activities. Their economic value is quantified by the value of assets spent on its creation and development, such as education, training, vocational training, skills, health, etc. Empirical observations confirm that increasing the value of these indicators shows similar development trends as those observed in the development of economic performance. The OECD (2020) justifies this by the stability of the percentage share of education expenditure in gross domestic product (GDP) across world economies.

With the growing performance of economies, this logically means an increase in the absolute amount of investment in human resources. At the same time, the share of the middle- and university-educated population entering the labour market has been growing for a long time. Thus, it can be concluded that there is a directly proportional relationship between the extent or value of human assets on the one hand and the productive (growth) capacity of the economic system on the other. However, proving its correctness requires correctly defining the attributes of human capital. This means identifying these attributes with the number of resources used to generate human capital, such as public or private expenditure on education (Dissou et al., 2016), years of schooling (De La Fuente & Doménech, 2000; De La Fuente & Doménech, 2006), or staffing of the educational process (Ehrenberg et al., 2001). Alternatively, it is possible to characterise the quality of human capital by indicators that in a way quantify the efficiency of resources spent, e.g., changes in labour productivity (Benhabib & Spiegel, 1994) or the scope of innovative activities (Romer, 1989; Blundell et al., 1999). Naturally, the choice of any indicator is associated with the risk of inappropriate selection due to abstracting from the essential facts that affect the creation and actual use of human capital. This risk is reduced by the multifactor assessment of human capital (OECD, 2020), which, in addition, makes it possible to identify barriers to its possible positive economic effects in the socio-economic system (Funke & Strulik, 2000).

De La Fuente and Doménech (2000; 2006) found a statistically significant positive correlation between production and human capital by analysing a series of OECD data for the period 1971–1998. Bassanini et al. (2001) revealed that the one-year increase in school attendance was accompanied by a 6 % increase in GDP per capita. Although Benhabib and Spiegel (1994) did not find a significant impact of human capital on GDP growth per capita, they state its positive impact on human productivity and sales (Freňáková et al., 2010). Romer (1989) also came to this conclusion by observing the relationship between human capital and the internal rate of innovation. The view of Nelson and Phelps (1966) that human capital affects the rate of technology diffusion was confirmed in a study by Funke and Strulik (2000), who explored the positive impact of growing human capital equipment on reducing a country's lag behind the technological development of other countries. Blundell et al. (1999) also believe that the rate of economic growth depends on the rate of accumulation of human capital and innovation, the source of which is the supply of human capital and the level of education. Educational attainment is the most common and striking example of human capital growth (Delgado et al., 2014). The problem of economic development remains a major problem for the mankind and for the economy as a science (Acemoglu, 2012).

In this paper we examine the role of education and innovation in the economic growth of Slovakia and other Visegrád (V4) countries. We will try to find answers to the questions about the existence of a causal link between some attributes of human capital and economic growth and the conditions under which its positive effects can be expected.

Methods and Problems for Determining the Impact of Human Capital on Economic Growth

The literature on the relationship between economic growth, quality, and quantity in the economic activities of human resources reveals a broad methodological series from Solow's structural econometric models, extended by Mankiw, Rommer and Weil (1992), known as MRW models, through convergence analyses proposed by Barro and Sala-i-Martin (1992) to panel models used for comparisons among countries (Islam, 1995). The suitability of using any of these methods depends on the purpose of the analysis, the availability of the variables considered and the method of their calculation. However, there is a consensus that the rate of economic growth is directly dependent on human capital, with the current partial influence of other factors, which can be generally attributed to the relationship (1):

$$g = rH + X\beta + \varepsilon, \quad (1)$$

where g is the rate of economic growth, H is human capital, X denotes other factors, ε is a stochastic element, r and β are unknown parameters to be estimated.

The choice of a representative indicator used to measure human capital can be considered important from the point of view of the reliability of findings and conclusions. Based on the performed research, it is possible to state the variability in the approach of the authors: Barro and Lee (1993), Islam (1995) used the average number of years of schooling over the age of 25 as a representative of human capital. The use of years of schooling in comparisons among countries has some disadvantages. It is not known exactly whether the knowledge acquired in one year of schooling in one country matches the knowledge gained in another country to ensure comparability of data. It is also assumed that knowledge is only achieved at school, ignoring other sources of training. In addition, it is often difficult to determine the average number of years of schooling. It is therefore appropriate to replace this indicator by a primary, secondary, and tertiary enrolment rate or by a literacy rate. This approach is used by scientists, e.g., Angrist et al. (2019), when they evaluate the development in the supply of human capital through the number of enrolments in individual levels of education.

Nonnemen and Vanhoudt (1996) and Sokolov-Mladenović et al. (2016) consider the share of education expenditure in GDP as a suitable and sufficiently representative indicator for this purpose. While Nonnemen and Vanhoudt (1996) state that the relationship between human capital and economic growth is negligible, an increase in research and development (R&D) expenditure as a percentage of GDP of 1 % has led to a 2.2 % increase in real GDP growth. Murthy and Chien (1997) quantify human capital using the weighted average share of the population registered in tertiary, secondary and primary education. By analysing the relationship among these independent variables and economic growth, they found significant positive and direct links with economic growth. Izushi and Huggins (2004), Blanco et al. (2013) used the number of people in private sector R&D as a representative for human capital, while Oketsch et al. (2014) and Holmes (2013) used the proportion of university graduates in total workforce. Hanushek and Kimko (2000) and Hanushek and Woessmann (2012) consider it more appropriate to evaluate human capital through indicators that characterise the quality of education. To verify the impact of human capital on economic growth, they use it as an independent variable that describes human capital through the evaluation of learning outcomes by the Programme for International Student Assessment (PISA) tests. Such a choice of the independent variable is based on Shultz and Hanushek (2012) research finding a two percent difference in the GDP growth rate per capita with a deviation of 100 points in the PISA results.

The partial influence of quantitative and qualitative indicators of education is indicated by the results of an OECD (2020) study, according to which there is a positive correlation between years of schooling and PISA results: analysis found that while 200 PISA points correspond to an average of six years of schooling, 300 points correspond to seven years of schooling. Similarly, according to the conclusions of this study, there is a relationship between PISA performance and life chances of respondents. The wide range of characteristics of the educational process has demonstrated their comprehensive impact on economic growth. This is confirmed by the fact that each of these complexes of factors has its justification in quantifying the supply of human capital. In its report named Global Human Capital Report (WEF, 2017), the World Economic Forum takes a comprehensive approach, quantifying the supply of human capital by determining the partial effects of several factors.

The correctness of such a conclusion is questionable. According to Glaeser et al. (2004) and OECD (2020), the causality of the relationship between education and economic growth and the significance of such a causal relationship have not been sufficiently confirmed. Therefore, another shortcoming is the use of inappropriate econometric techniques to demonstrate the existence or magnitude of the impact of education on economic growth.

At the methodological level, there are also discussions about the correct use of logarithmic values to quantify the impact of independently assessed variables expressing the size of human capital. According to De La Fuente and Ciccone (2003), the use of logarithmic values results in an underestimation of coefficients and an error in assessing the impact of education on economic growth. Similarly, they note the differences in findings and conclusions regarding the selection of the variable used to quantify human capital, which they illustrate by the differences in the values of the alternative indicators.

We set the hypothesis that there is a relationship between human capital and economic growth. According to mentioned research, we analysed the following indicators in the area of human capital: education expenditures, ratio of students to teachers, share of workers with secondary education, expenditure on research and development, number of employees in research and development, and number of registered patents per million inhabitants.

Results

In line with the theme outlined in the introduction, the aim of the study was to identify differences in the relationship between human capital and economic growth across the V4 population and to identify their causes.

When analysing the impact of human capital on economic growth, we assume that the level of students' abilities does not differ across the group. Therefore, in this paper, the different abilities of the human factor are considered to be a consequence of the different scope and quality of its development in the processes of education and skills development. Based on the methodology used by De La Fuente and Doménech (2000), Hanushek and Kimko (2000), and Pelinescu (2015) in their analyses, we consider the volume of resources used to finance education, the ratio of teachers to students and the availability of higher education (monitored by the share of the population with achieved secondary and tertiary level of education). At the same time, we assume that the impact of the human factor on economic growth is positively correlated with the support and scope of science and development. Based on this assumption, we also consider the number of employees in science and research and the volume of resources used to finance science and research as attributes of the human factor that increase economic growth. When choosing variables, we monitored the availability and comparability of data. We applied a function-based model to this data (2):

$$GDPpercap = \alpha \times H + \beta \times X + \theta i + \varepsilon, \qquad (2)$$

where *GDPpercap* is real GDP per capita and is a direct function of human capital (*H*), other factors (*X*) and the stochastic element ε. α, β are parameters to be estimated, θ_i is a constant quantifying time effects and regional specifics.

This approach used in the works of Hanushek and Woessmann (2012) and Pelinescu (2015) allows a direct expression of the elasticity of the dependent variable GDP per capita to changes in the examined independent variables.

The model uses data describing the creation of real GDP per capita (in s.c. 2015) in the annual periodicity for the period 2000–2019. According to the UNESCO (2020, p. 149), this indicator correlates positively with a country's ability to develop a knowledge-based society. In order to compare the performance of economies and the trends of their development, we firstly present brief descriptive statistics of traditional indicators of economic growth (Table 1).

Table 1

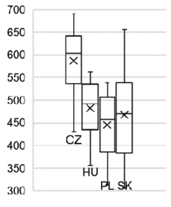
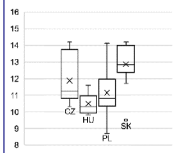
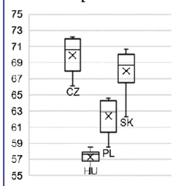
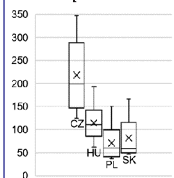
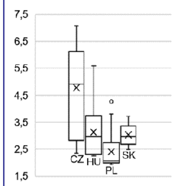
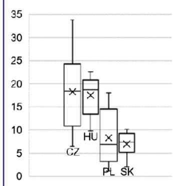
Descriptive statistics of GDP

	CZ	*HU*	*PL*	*SK*
GDP (th. EUR per empl)				
Obs.	20	20	20	20
average	31.76	25.80	23.35	27.81
median	32.58	26.26	22.78	28.63
min	24.96	21.22	17.41	20.04
max	37.90	29.04	30.63	34.04
var (*x*)	0.12	0.08	0.16	0.16
g_GDP (%)				
Obs.	20	20	20	20
average	2.65	2.77	3.77	3.88
median	2.33	4.24	3.76	3.81
min	–5.23	–6.57	1.24	–5.63
max	6.45	5.28	7.14	10.74
var (*x*)	1.04	1.05	0.44	0.86
skewness	–1.19	–2.05	0.17	–0.79
kurtosis	2.61	5.08	–0.50	3.34

Source: own processing based on Eurostat (2020a; 2020b), OECD (2020) and UNESCO (2020) data.
Labelling used: CZ — Czech Republic, HU — Hungary, PL — Poland, SK — Slovakia.

Table 2

Descriptive statistics of human capital indicators

	ExpEdu 	*StuTea Ratio* 	*EmplSec* 	*ExpR&D* 	*R&DPers* 	*Patents* 
average	495.57	11.56	64.41	121.40	7.03	12.76
median	501.07	11.13	64.55	108.79	6.22	10.95
min	304.98	8.70	55.20	37.10	4.26	1.13
max	690.48	14.11	72.20	347.04	13.84	33.78
var(x)	0.19	0.12	0.08	0.61	0.33	0.80
skewness	–0.01	0.35	–0.25	1.27	1.17	1.53
kurtosis	–0.62	–0.93	–1.35	1.19	0.58	2.39
Obs.	72	74	80	72	76	72

Source: own processing based on Eurostat (2020a; 2020b), OECD (2020) and UNESCO (2020) data.
Labelling used: ExpEdu — expenditure on education, StuTeaRatio — ratio of students to teachers, Empl_SecTer — share of workers with secondary education, ExpR&D — expenditure on research and development, R&DPers — number of employees in research and development, Patents — number of registered patents per million inhabitants. The variables considered represent the share of the total value per 1000 persons (in the case of patents per share per million persons). CZ — Czech Republic, HU — Hungary, PL — Poland, SK — Slovakia.

As partial indicators for the variable human capital there were considered expenditures on education in € per capita (*ExpEdu*), the index ratio of the number of students and teachers (*StuTeaRatio*) in 1–3 levels of education (International Standard Classification of Education (ISCED) 2011 classification), share of workers with secondary education per 1000 employed workforce (*EmplSec*), number of employees with tertiary education per 1000 employed workforce (*EmpTer*), expenditure on research and development (*ExpR&D*) in € / inhabitant, number of persons with tertiary education in research and development per 1000 workforce (*R&DPers*) and number of registered patents (*Patents*) per million inhabitants. The number of registered patents per 100 thousand inhabitants (*Pat*) is also monitored in order to compare the efficiency of resources for the development of human capital. The data source was the databases of Eurostat, OECD, UNESCO and WEF. The period of 2010–2019 was monitored, data were obtained on an annual basis. Descriptive statistics of the monitored variables are given in Table 2.

Descriptive statistics of the data series showed differences in the variability of values across the set of variables, the standard deviations vary depending on the unit and the indicator used.

The differences also resulted from the comparison of data panels across the set of countries. In the next step, the tightness of the relationship between the dependent variable GDP per capita and the considered factors of the human capital reserve was verified on the partial data sets created for the individual countries of the sample. The results confirmed the link between economic growth and human capital: in all V4 countries, a very large to near-perfect dependence of economic growth on the number of researchers, R&D expenditure, the number of workers with secondary (and tertiary) education and the number of patents filed was observed. Across the set of countries, a different impact on GDP per capita was found for the commonly used indicators of education expenditure and the number of students per teacher (Table 3).

The acquired knowledge was applied in compiling a set of mutually independent variables, explaining the mechanisms of the effects of human capital on the performance of the economic system and its growth and revealing critical points in the development of human capital in the evaluated economies. Meeting these requirements is a set of variables that:

1. shape the capabilities of human capital with resource support in the process of education and skills development — expenditure on education, expenditure on research and development, personnel provision of the educational process, personnel provision of research and development,

2. quantify the supply of human capital — the size of the workforce that achieved secondary and tertiary education,

3. quantify the outputs of human capital formation processes — the number of patents filed.

Table 3

Correlations between the dependent variable and the factors of human capital reserve

indicator	r_s			
	CZ	***HU***	***PL***	***SK***
Exp_Edu	0.86	0.41	0.98	0.95
TeaStu_Ratio	0.78	0.26	0.79	0.25
Empl_Sec	–0.49	0.76	–0.13	0.16
Empl_Ter	0.89	0.83	0.98	0.97
Empl_Sec&Ter	0.99	0.94	0.96	0.97
R&D_Pers	0.97	0.83	0.82	0.89
Exp_R&D	0.90	0.90	0.95	0.84
Patents	0.95	0.79	0.97	0.90

Source: own processing based on Eurostat (2020a; 2020b), OECD (2020) and UNESCO (2020) data.

This satisfies the regression model described by (3):

$$GDPpercap = \alpha_1 ExpEdu + \alpha_2 StuTeaRatio + \\ + \alpha_3 R\&DPers + \alpha_4 ExpR\&D + \\ + \alpha_5 EmpTer + \alpha_6 Patents + \beta GDPpercap_{t-1} + \\ + \theta i + \varepsilon. \quad (3)$$

where *GDPpercap* is real GDP per capita, *ExpEdu* is expenditure on education, *StuTeaRatio* is the ratio of students to teachers, *EmplTer* is the share of workers with tertiary education, *ExpR&D* is expenditure on research and development, *R&DPers* is the number of employees in research and development and *Patents* is the number of patents filed. The variables considered represent the share of the total value per 1000 persons (in the case of patents, the share per million persons)

Multiple regression analysis performed on the regression model specified in this way examined the impact of human capital reserves, the conditions of its creation, its use and productivity on GDP per capita across the set of countries. In all cases, only the number of patents filed (per million inhabitants) had a positive effect on the value of GDP per capita, although this varied in size across the V4 group. On this basis, it can be deduced that none of the variables considered appears to be a general assumption of a strong positive impact of human capital on value creation. The findings are presented in Table 4.

Based on the findings, the human capital variable must always be specified individually for each economy. In our case, this means the specifications expressed by the relations (4–7):

$$CZ: HC = f\{ExpR\&D;\ R\&DPers;\ Patents\}, \quad (4)$$

$$HU: HC = f\{ExpEdu;\ StuTeaRatio;\ EmplSec;\ ExpR\&D;\ Patents\}, \quad (5)$$

$$PL: HC = f\{ExpEdu;\ EmplSec;\ R\&DPers;\ Patents\}, \quad (6)$$

$$SK: HC = f\{EmplSec;\ ExpR\&D;\ R\&DPers;\ Patents\}. \quad (7)$$

Table 4

Significance of the impact of the variable on GDP generation

	CZ	***HU***	***PL***	***SK***
ExpEdu		***	**	
StuTeaRatio		***		
EmplSec		***	***	***
ExpR&D	***	***		***
R&DPers	***		***	***
Patents	***		**	***

Source: own processing based Eurostat (2020a; 2020b), OECD (2020) and UNESCO (2020) data

Across the set of countries, the vectors of the variable human capital constructed in this way resulted from a multiple regression analysis as best describing its real impact on the size of the GDP per capita of these countries. The degree of their influence, specified in the values of the regression coefficients of the loglinear regression model, is given in Table 5.

The findings of the analyses identify the relationship at three levels: the impact of inventory, the impact of human capital formation conditions and the impact of the efficiency of the use of available human capital reserves.

Undoubtedly interesting is the finding of ambiguity in the influence of the conditions of human factor creation on its effects. This finding suggests that education expenditure, considered a key factor in human skills development, does not appear to be a clear factor in the positive impact of the human factor on economic performance. The statistically significant elastic response of economic growth to their impact was demonstrated only in economies, with a stable trend of their positive development and low volatility of their share in GDP. The low impact of education expenditure on economic growth has its origins in several factors: the first problem is its limited use for comparison across a diverse sample, because in this form, it does not take into account specific con-

Table 5

Impact of human capital on economic growth

	CZ	*HU*	*PL*	*SK*
Location constant	9.651	3.675	1.678	–2.990
Variable	Regression coefficients α_{ij}			
ExpEdu	—	0.227	0.590	—
StuTeaRatio	—	–0.439	—	—
EmplSec	—	0.640	0.625	1.817
ExpR&D	–0.198	0.298	—	0.206
R&DPers	0.233	—	0.177	0.653
Patents	0.222	0.080	0.098	0.121
R-squared	0.980	0.965	0.992	0.980

Source: own processing based on Eurostat (2020a; 2020b), OECD (2020) and UNESCO (2020) data.

ditions such as economic performance and the needs based on the number involved in the education process. The reliability of the assessment is disputable by comparing the share of education expenditure on GDP due to the different performance of the analysed countries. This fact also reduces the reliability of the information. The third, often discussed fact is that this indicator does not indicate their use or their redistribution between different levels of education. Our findings can be illustrated by the observed linear impact of education expenditure in primary and secondary education and their slightly exponential impact in tertiary education.

Another important finding related to the conditions of human capital formation is the statistically unproven significance of the influence of the variable number of students per teacher. This was increasing, mainly due to the increasing number of students in tertiary education. From the point of view of economic consequences, in the analysed group of countries, the variability of its values in the interval var_x1–3 % appears to be a significant regressor of influence only in the case of Hungary. This finding correlates with several published findings, according to which a change (reduction) in class size is reflected only in the case of a significant change and not in all areas of study in the same way (Krueger, 2003; Urquiola, 2001). This means, that the quality of graduates does not only depend on the number of students per teacher, its source is a set of quality attributes, including the quality of processes and the quality of their staffing (Anderson et al., 2016).

The reason for the low elasticity of economic growth to build human capital can be seen in labour migration outside the domestic labour market. Labour migration changes the productivity of source support spent on building human capital — the effect of labour migration is about 40 thousand persons outside their own territory. In this case is not only a loss of about 0.3–2 % of the share (across countries of the sample differently) of secondary and tertiary educated workforce, but with demonstrated elasticity (Table 5) of GDP generation to changes in employment and reduction of economic performance by 0.2–0.6 %. The direction of migration flows and the value of remittances (approximately $550 billion to low- and middle-income countries in 2019) (IMD, 2009) reduces the estimate of economic damage but does not eliminate the waste of skills.

Low resource support for research and development also appears to be a waste of skills. The observed 0.9 % (*SK*, *PL*) — 2 % (*CZ*) share of expenditure on research and development does not reach its average value in the EU Member States (2.18 %). Despite the findings, the values of the regression coefficient quantify its positive, statistically significant impact on the economies of countries with a low level of support at the beginning of the analysed period and comparable trends in its development at the end of the analysed period. From the point of view of economic effects, high R&D support appears to have a negative effect on economic growth (as indicated by the value of the regression coefficient for this indicator in *CZ*). Both are similar, as according to the general opinion on the nature of their effect, R&D expenditures will be reflected only in the longer term, in the short term their effect is weak (Huňady & Orviská, 2014). Also, we present findings of differences in the number of patents (filed per million inhabitants) and its development across the file. The values of the regression coefficient identify its strongest influence in the economy, in which a relatively high source of support (financial and personnel) was provided at the beginning of the analysed period. The lower level of support changes into lower productivity of the human factor, assessed both by the number of patents and the degree to which this determinant has an impact on economic growth.

The findings on the impact of the number of people with secondary (alternatively tertiary) education on economic growth pointed to the importance of the actual use of the existing human capital reserve on the economic growth of the system. Regression analysis confirmed our assumption. A larger and statistically significant impact on economic growth was found for the group of workers with secondary education, which has a 57.3–69.9 % share in the number of workers (across the group differently). Compared to these values, only a small share (14.7–18.6 %) of people with tertiary education is reflected in the weakening of the influence of this group of workers on economic growth. Its size can be assessed as statistically insignificant. In addition to the above, the possible weakening of the impact of the tertiary educated on economic growth is a result of the structural problems manifested by inefficient use of a highly educated workforce, as Hanushek and Woessmann (2007) point out in the case of another set of countries. These results are consistent with the findings of Barro (2001) and Son et al. (2013) who state that the inefficient use of a highly educated workforce leads to its frustration and low labour productivity (Leuven & Oosterbeek, 2011; Simionescu & Naroș, 2019). In addition, as in the case of R&D support effects, a longer period of time for these positive effects must be expected.

Conclusion

The results of the analysis of the relationship between the reserve and the level of human capital in the set of V4 countries in the period 2000–2019 can be summarised in several points.

We analysed the hypothesis that there is a relationship between human capital and economic growth. In the area of human capital, we analysed the following indicators: expenditure on education, ratio of students to teachers, share of workers with secondary education, expenditure on research and development, number of employees in research and development, and number of registered patents per million inhabitants.

Since we compiled and examined the variable human capital from several indicators, it is not possible to adopt relevant conclusion on the established hypothesis.

In particular, the model revealed a positive, statistically significant relationship between GDP per capita and the innovative capacity of human capital (proved by the number of patents) and the qualifications of employees.

Proven, though controversial, is the ambiguous relationship between education expenditure and GDP (both observed in ratio indicator, per capita). Similar findings may lead to considerations about the methodological correctness of defining the dependence of economic performance on education. However, they have a simple reason — the educational process takes several years (approximately 20 years) and the process of developing abilities and skills continues after this period. Therefore, in line with the findings of others (e.g. Pritchett, 1995), we consider the already stated delay in the effects of resource support for education as a fact to be taken into account in constructing econometric models, but not a finding that would deny the positive effects of education on the economic system. In addition, as in this case, other similar findings are usually obtained from data from economies with structural problems (De La Fuente & Doménech, 2000). In such a case, the low absorption capacity of labour markets and the associated non-utilisation of labour are behind the unproven importance of R&D expenditure. As another reason for the identified ambiguity of the relationship, we identify multifactor human capital formation. With variability across economies, this necessarily means, on a case-by-case basis, a specific set of human capital attributes that significantly affect the performance and growth of the economic system.

The low level of coefficients leads us to a conclusion identical to the opinion of Odit et al. (2010), according to which the impact of human capital creation and development tools extends over a longer period and is reduced by the simultaneous action of other labour market factors.

In the context of the above, the contradiction of some findings leads us to the conclusion that these are always comprehensively influenced by a set of characters. Therefore, in the model for characterising the supply and use of human capital, their individual sets were used for each of the economies.

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