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The Impact of Educational Factor on Innovation and Competitiveness of Middle-Income Countries

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Abstract:

Purpose: *The main purpose of the paper is to analyze the educational factor's impact on innovation and competitiveness of an economy, with reference to developing countries, which are counted among the group of middle gross national income (GNI) per capita economies.*
Design/methodology/approach: *Data covering the period 2018-2019 have been utilized, where applicable, and as measures of educational factor the following sub-indices have been adopted: two main pillars and one sub-pillar of GTCI, two sub-pillars of GII, as well as the sixth pillar of GCI. Research has been carried out using the following methods: data normalization, linear and multiple regression analyses, partial correlation analysis.*
Findings: *Clear relationships between education, innovation and competitiveness have been confirmed based on available statistical data. Economy grouping's peculiarities depend on their stage of socio-economic development: high quality education is important for all countries, but in high income economies with knowledge and information-based economy the role of higher education and sophisticated professional skills seem to be predominant, whereas general education and vocational skills importance can be observed for middle income followers.*
Practical implications/limitations: *Due to paper requirements and restricted data availability research has been based only on the latest data concerning the period 2018-2019. If the research had included level 2 components of GII, GCI and GTCI, obtained results would have been more accurate and meaningful, although paper volume would have been significantly exceeded. Promising area of future interest are pandemic consequences for education-driven innovation and competitiveness, but such assessments can be possible in years to come, probably even after a decade.*
Originality/value/contribution: *The role of education has been analyzed in the context of other non-educational components of selected global indices. Apart from presenting their quite strong correlations, some differences between country groups have been also emphasized, i.e., in what degree different education-related factors can influence their innovation and competitiveness capacities.*

Keywords: *Education, innovation, competitiveness, middle income economies.*

JEL Classification: *F63, O31.*

Paper type: *Research article.*

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1. Introduction

In recent decades there was a noticeable geopolitical shift in the world economy and international trade, i.e., growing importance of so called newly industrialized, especially Asian economies. Despite the global protectionism awakening, integration process slowdown (and even its reversion in case of NAFTA or European Union), growing economic imbalance and social inequality, as well as pressing climate change-related problems, more and more developing countries have strived to catch up not only leading Asian economies, but some of developed ones as well (Ghosh, 1996; Dicken, 2011). The global crisis caused by COVID-19 pandemic in 2020 will probably leave its imprint on the world economy in years to come, therefore thoughtful actions undertaken by many different stakeholders can reduce negative pandemic consequences, thus have positive effects on innovation and competitiveness.

The main purpose of this research is to analyze the educational factor impact on innovation and competitiveness of an economy, with reference to the developing countries counted among the group of middle gross national income (GNI) *per capita* economies (according to the World Bank classification). The former part has been devoted to the overview of selected indices, namely Global Innovation Index (GII), Global Competitiveness Index (GCI), and Global Talent Competitiveness Index (GTCI), along with comparative analysis of their frameworks and a brief theoretical background. The middle part, however, includes the discussion of multiple regression analysis results based on GII 2019, GCI 2019, and GTCI 2020 sub-indices, especially those related to the education policy. Finally, the latter part has been dedicated to the linear regression analysis between calculated education index (EDU) and selected global innovation and competitiveness indices.

2. Theoretical Background

The interconnections between education, competitiveness and innovation have been in fact the subject of comprehensive international research for a long time. For example, some research, especially at the beginning of the present century, indicated growing role of education, mainly higher education, in catching up process of the four East Asian tiger economies (Cantwell, 2005). As concerns innovation-driven economic growth, education can influence not only inventive efforts of giant organizations like transnational corporations, but of independent, smaller inventors and their entrepreneur partners as well (Carneiro, 2000; Baumol, 2005). Moreover, the still growing importance of highly educated workers in promoting technological and scientific progress and consequently economic growth could have been observed in both developed and still developing economies (Brunello *et al.*, 2007; Chi and Qian, 2010). While the links between higher education, sophisticated technical skills, innovation, and socio-economic growth seem to be obvious and undisputable, one can also discover some interesting research on role of humanities and social sciences in knowledge production. To be exact, technical studies play important roles in all four types of innovation (i.e., product, process, organizational, and marketing ones), whereas humanities and social sciences are particularly relevant in product, organizational and marketing innovation (Junge *et al.*, 2012).

In terms of education relevance to competitiveness, research works concerning both secondary and tertiary education importance in this area can be found. For instance, the analysis based on PISA results from 63 countries leads to the main conclusion that educational achievement explains 54% of competitiveness, and academically and in competitiveness East Asian and Anglo-Saxon countries are still ahead of Europe, the rest of Asia, and South/Central America (Baumann and Winzar, 2016). Experience of European countries shows that education makes a three-fold contribution to a country's economic health: it is beneficial for employment rates, it is a key driver for long-term economic growth, and it appears to be beneficial for social cohesion.

Therefore, attaining higher levels of tertiary education and increasing the quality of education should be crucial for present and upcoming European competitiveness (Roth and Gros, 2008). On the other hand, increased standardization of teaching and learning may be counterproductive to the expectations of enhanced economic competitiveness. Competition between education systems, schools and students should be replaced by networking, deeper co-operation, and open sharing of ideas at all levels, if the role of education in economic competitiveness is to be strengthened (Sahlberg, 2006).

For commenting on this theoretical background and verifying the paper's purpose, three commonly known and appreciated composite indicators have been selected, i.e., Global Innovation Index (GII), Global Talent Competitiveness Index (GTCI), and Global Competitiveness Index (GCI). Their frameworks are presented in Figure 1, and the number of incorporated metrics is shown in parenthesis, where appropriate.

Global Innovation Index has been calculated and published for more than decade, and in 2019 edition it provides detailed innovation metrics for 129 economies. All economies covered represent 91.8% of the world's population and 96.8% of the world's GDP (Cornell University, INSEAD, and WIPO, 2019). The overall GII consists of the Innovation Input Sub-Index and the Innovation Output Sub-Index. The former is comprised of five pillars that capture elements of the national economy enabling innovative activities (columns 1-5 in Figure 1), whereas the latter provides information about outputs that are the results of innovative activities within economies (columns 6-7 in Figure 1).

Figure 1. *Comparison of GII, GTCI and GCI frameworks*

Global Innovation Index (GII) framework (80)						
Institutions (7)	Human capital and research (12)	Infrastructure (10)	Market sophistication (9)	Business sophistication (15)	Knowledge and technology outputs (14)	Creative outputs (13)

1.1 Political environment (2)	2.1 Education (5)	3.1 Information & communication technologies (4)	4.1 Credit (3)	5.1 Knowledge workers (5)	6.1 Knowledge creation (5)	7.1 Intangible assets (4)
1.2 Regulatory environment (3)	2.2 Tertiary education (3)	3.2 General infrastructure (3)	4.2 Investment (3)	5.2 Innovation linkages (5)	6.2 Knowledge impact (5)	7.2 Creative goods & services (5)
1.3 Business environment (2)	2.3 Research & development (R&D) (4)	3.3 Ecological sustainability (3)	4.3 Trade, competition, & market scale (3)	5.3 Knowledge absorption (5)	6.3 Knowledge diffusion (4)	7.3 Online creativity (4)

Global Talent Competitiveness Index (GTCI) framework (70)					
Enable (19)	Attract (11)	Grow (14)	Retain (7)	Vocational and technical skills (8)	Global knowledge skills (11)
1.1 Regulatory Landscape (5)	2.1 External Openness (5)	3.1 Formal Education (5)	4.1 Sustainability (3)	5.1 Mid-Level Skills (4)	6.1 High-Level Skills (6)
1.2 Market Landscape (6)	2.2 Internal Openness (6)	3.2 Lifelong Learning (3)	4.2 Lifestyle (4)	5.2 Employability (4)	6.2 Talent Impact (5)
1.3 Business and Labor Landscape (8)		3.3 Access to Growth Opportunities (6)			

Global Competitiveness Index (GCI) framework (103)			
1st pillar: Institutions (26)	4th pillar: Macroeconomic stability (2)	7th pillar: Product market (7)	10th pillar: Market size (2)
2nd pillar: Infrastructure (12)	5th pillar: Health (1)	8th pillar: Labor market (12)	11th pillar: Business dynamism (8)
3rd pillar: ICT adoption (5)	6th pillar: Skills (9)	9th pillar: Financial system (9)	12th pillar: Innovation capability (10)

Source: *Own presentation based on (Cornell University, INSEAD, and WIPO, 2019, p. 207; INSEAD, 2020, pp. 10-11; World Economic Forum, 2019, pp. 2-3).*

Global Talent Competitiveness Index methodology is based on the *talent competitiveness* concept, which *"refers to the set of policies and practices enabling a country to develop, attract, and empower the human capital that contributes to productivity and prosperity"* (INSEAD, 2020). As in the case of GII, GTCI utilizes an Input-Output model: former four pillars are incorporated in the Talent

Competitiveness Input Sub-index, latter two ones – constitute the Talent Competitiveness Output Sub-index. In other words, input pillars describe the policies, resources, and efforts that can be used to foster talent competitiveness of given country. On the other hand, output pillars relate to the talent quality and the skills developed in the process of talent management.

Global Competitiveness Index was introduced in 1979 and in its latest form called GCI 4.0 provides guidance for policymakers and other stakeholders on what matters for long-term growth. It can advise policy choices, help shape holistic economic strategies and monitor progress over time (World Economic Forum, 2019). In contrast to GII and GTCI, GCI 4.0 framework is organized into 12 pillars, which encompass main drivers of productivity. According to the World Economic Forum, current edition of GCI reflects the growing significance of factors connected to the Fourth Industrial Revolution (4IR), mainly human capital and innovation.

Those briefly described indices are presented in Figure 1, where the pillars connected to the educational area have been marked in grey. It is worth emphasizing that educational metrics are mostly apparent in the GTCI framework (28 out of 70). It is, however, quite understandable, taking into consideration the "talent-oriented" nature of this indicator. Wide range of areas included in GII and GCI makes these indices much more versatile, so education-related metrics' under-representation should not be surprising.

3. Research Methods

In the paper statistical data covering the period 2018-2019 have been utilized, where applicable. As the measures of educational factor, the following sub-indices have been adopted: two pillars (Grow, Vocational and technical skills) and one sub-pillar (High level skills) of GTCI, two sub-pillars of GII (2.1 Education and 2.2 Tertiary education), and the sixth pillar of GCI (Skills). All included calculations have been completed using Statistica 13.1 software. Multiple regression analysis has been based on all level 1 sub-indices of GII, GTCI and GCI, with special regard to the above mentioned, education-related sub-indices. To conduct linear regression analysis the composite education index had to be calculated. Values of all pillars and sub-pillars recognized as education-related ones had been initially normalized, then education index (EDU) was calculated as the simple arithmetic average of those normalized values.

Table 1. *World Bank classification for selected years in 1990-2019*

Income group	Gross National Income (GNI)* *per capita* (in USD)			
	1990	2000	2010	2019
Low income	<= 545	<= 760	<= 975	<= 1,035
Lower middle income	546-2,200	761-3,030	976-3,855	1,036-4,045
Upper middle income	2,201-6,000	3,031-9,360	3,856-11,905	4,046-12,535
High income	> 6,000	> 9,360	> 11,905	> 12,535

[*] In FY02, a change in terminology was made to be in line with the 1993 System of National Accounts (SNA); the definition of GNI per capita remains the same as the previously used gross national product (GNP) per capita (World Bank, 2020b).
Source: *World Bank, 2020a.*

Here there is a need for some clarification, why for further analyses country groups classified by GNI *per capita*, rather than developed and developing countries, have been chosen. For a long time, traditional division on developed and developing economies seemed to be unclear and obsoleted, because affiliation to one of those groups does not result from any unambiguous and indisputable criteria (United Nations Statistics Division, 2019). Such evident criterion, namely gross national income *per capita*, has been adopted by the World Bank. Although classification presented in Table 1 had been internally used for analytical purposes since late eighties of 20th century, only very recently it turned into World Bank official standpoint (Prydz and Wadhwa, 2019). It should be therefore added that GNI *per capita* thresholds are verified and amended every year. In 2019 classification 76 economies were included in high income group, 51 – in upper middle-income group, 41 – in lower middle-income group, and only 26 in low-income group. Additionally, for last two decades the high-income group has grown by more than 50%, and at the same time the combined low and lower middle-income groups have shrunk almost twofold (Gryczka, 2020). Only this can be treated as a minor, indirect evidence of growing role of previous "developing" countries in the global economy.

4. Research Findings

4.1 Multiple Regression Analysis Results

In the following tables multiple regression analysis results have been presented for GII 2019, GTCI 2020 and GCI 2019, respectively. For better result interpretation source data were divided into three groups – for high income (HI), upper middle income (UMI) and lower middle income (LMI) economies. Pillars of corresponding global indices have been used as independent variables, and rows related to the education have been bolded. All calculated b* values are statistically significant. Variables with the lowest tolerance (i.e., highest R^2 values) are marked in dark grey, whereas variables with the highest tolerance (i.e., lowest R^2 values) are marked in light grey. The same convention has been used in Tables 2-4.

Table 2. *Multiple regression results for GII 2019 (HI, UMI and LMI economies)*

Dependent variable: GII 2019 (HI); Multiple R = 0.99999624; F = 171135.7							
R^2 = 0.99999249; df = 21.27; no. of cases: 49; Corrected R^2 = 0.99998664; p = 0.000000							
Standard estimation error: 0.036472388							
Absolute term: -0.153464912; Standard error: 0.1293700; t(27) = -1.186; p = 0.2459							
Variable	b* (value)	Partial correlation	Semi-partial correlation	Tolerance	R^2	t(27)	p

1.1	0.040	0.974	0.012	0.088	0.912	22.522	0.000
1.2	0.040	0.978	0.013	0.101	0.899	24.301	0.000
1.3	0.036	0.988	0.018	0.239	0.761	33.655	0.000
2.1	**0.027**	**0.990**	**0.019**	**0.483**	**0.517**	**36.185**	**0.000**
2.2	**0.038**	**0.996**	**0.032**	**0.680**	**0.320**	**60.105**	**0.000**
2.3	0.084	0.993	0.022	0.071	0.929	42.364	0.000
3.1	0.028	0.981	0.014	0.235	0.765	26.158	0.000
3.2	0.036	0.994	0.024	0.465	0.535	46.138	0.000
3.3	0.035	0.991	0.020	0.327	0.673	38.178	0.000
4.1	0.057	0.996	0.029	0.264	0.736	55.707	0.000
4.2	0.044	0.995	0.026	0.367	0.633	49.969	0.000
4.3	0.030	0.983	0.015	0.241	0.759	27.897	0.000
5.1	0.052	0.989	0.018	0.125	0.875	34.983	0.000
5.2	0.050	0.991	0.020	0.159	0.841	37.961	0.000
5.3	0.043	0.986	0.016	0.141	0.859	30.878	0.000
6.1	0.181	0.999	0.052	0.082	0.918	98.091	0.000
6.2	0.093	0.998	0.050	0.288	0.712	94.388	0.000
6.3	0.159	0.999	0.066	0.173	0.827	125.381	0.000
7.1	0.103	0.999	0.057	0.301	0.699	107.466	0.000
7.2	0.079	0.998	0.050	0.397	0.603	94.188	0.000
7.3	0.123	0.999	0.055	0.199	0.801	104.222	0.000

Dependent variable: GII 2019 (UMI); Multiple R = 0.99999349; F = 43880.48

R^2 = 0.99998698; df = 21.12; no. of cases: 34; Corrected R^2 = 0.99996419; p = 0.000000

Standard estimation error: 0.035275394

Absolute term: 0.217912290; Standard error: 0.1524789; t(12) = 1.4291; p = 0.1785

Variable	b* (value)	Partial correlation	Semi-partial correlation	Tolerance	R^2	t(12)	p
1.1	0.053	0.991	0.027	0.256	0.744	25.901	0.000
1.2	0.058	0.997	0.047	0.681	0.319	45.547	0.000
1.3	0.058	0.996	0.039	0.451	0.549	37.335	0.000
2.1	**0.076**	**0.997**	**0.047**	**0.375**	**0.625**	**44.869**	**0.000**
2.2	**0.072**	**0.995**	**0.037**	**0.265**	**0.735**	**35.668**	**0.000**
2.3	0.081	0.987	0.022	0.072	0.928	20.952	0.000
3.1	0.070	0.993	0.031	0.193	0.807	29.443	0.000
3.2	0.054	0.989	0.024	0.199	0.801	23.252	0.000
3.3	0.046	0.991	0.027	0.339	0.661	25.641	0.000
4.1	0.056	0.991	0.027	0.229	0.771	25.633	0.000
4.2	0.081	0.998	0.052	0.402	0.598	49.517	0.000
4.3	0.058	0.987	0.022	0.149	0.851	21.406	0.000
5.1	0.084	0.994	0.034	0.163	0.837	32.323	0.000
5.2	0.032	0.986	0.021	0.419	0.581	20.128	0.000
5.3	0.047	0.979	0.017	0.139	0.861	16.721	0.000
6.1	0.171	0.998	0.061	0.129	0.871	58.839	0.000
6.2	0.187	0.999	0.079	0.179	0.821	75.773	0.000
6.3	0.127	0.998	0.054	0.180	0.820	51.680	0.000
7.1	0.255	1.000	0.127	0.248	0.752	122.007	0.000
7.2	0.123	0.998	0.059	0.231	0.769	56.672	0.000
7.3	0.085	0.996	0.042	0.247	0.753	40.676	0.000

Dependent variable: GII 2019 (LMI); Multiple R = 0.99999959; F = 115029.7

R^2 = 0.99999917; df = 21.2; no. of cases: 24; Corrected R^2 = 0.99999048; p = 0.000009							
Standard estimation error: 0.016842805							
Absolute term: -0.0141365; Standard error: 0.0842633; t(2) = -0.1678; p = 0.8822							
Variable	b* (value)	Partial correlation	Semi-partial correlation	Tolerance	R^2	t(2)	p
1.1	0.054	0.998	0.015	0.072	0.928	22.544	0.002
1.2	0.065	0.998	0.013	0.042	0.958	20.598	0.002
1.3	0.047	0.999	0.022	0.216	0.784	34.061	0.001
2.1	**0.097**	**0.999**	**0.028**	**0.082**	**0.918**	**42.976**	**0.001**
2.2	**0.081**	**1.000**	**0.031**	**0.146**	**0.854**	**48.117**	**0.000**
2.3	0.052	0.994	0.008	0.025	0.975	12.646	0.006
3.1	0.078	0.999	0.020	0.066	0.934	31.272	0.001
3.2	0.062	1.000	0.035	0.321	0.679	54.232	0.000
3.3	0.047	0.999	0.021	0.193	0.807	31.971	0.001
4.1	0.101	1.000	0.042	0.174	0.826	65.401	0.000
4.2	0.092	1.000	0.041	0.193	0.807	63.041	0.000
4.3	0.056	0.996	0.011	0.037	0.963	16.819	0.004
5.1	0.072	0.996	0.011	0.021	0.979	16.400	0.004
5.2	0.049	1.000	0.032	0.418	0.582	49.673	0.000
5.3	0.053	0.996	0.011	0.041	0.959	16.595	0.004
6.1	0.160	0.998	0.015	0.009	0.991	23.930	0.002
6.2	0.182	1.000	0.058	0.101	0.899	89.597	0.000
6.3	0.155	1.000	0.030	0.039	0.961	47.329	0.000
7.1	0.234	1.000	0.045	0.037	0.963	70.032	0.000
7.2	0.109	1.000	0.052	0.230	0.770	80.890	0.000
7.3	0.048	0.997	0.012	0.059	0.941	18.256	0.003

Source: *Own calculations based on (Cornell University, INSEAD, and WIPO, 2019, p. 207; INSEAD, 2020, pp. 10-11; World Economic Forum, 2019, pp. 2-3).*

Table 2 contains the results of multiple regression between GII 2019, and its pillars previously presented in Figure 1. For high income economies (upper part) partial and semi-partial correlation coefficient values indicate that variables 1.1 (Political environment), 2.3 (Research & Development) and 6.1 (Knowledge creation) contribute to the created model to the greatest extent, while variables 2.1 (Education), 2.2 (Tertiary education) and 3.2 (General infrastructure) – in the least. For upper middle-income economies (middle part) partial and semi-partial correlation coefficient values indicate in turn that variables 2.3 (Research & Development), 5.3 (Knowledge absorption) and 6.1 (Knowledge creation) contribute to the created model to the greatest extent, whereas variables 1.2 (Regulatory environment), 1.3 (Business environment), 4.2 (Infrastructure) and 5.2 (Innovation linkages) – in the least. Finally, as concerns lower middle-income economies (lower part), most of variables has extremely high contribution to the model, especially 6.1 (Knowledge creation), 5.1 (Knowledge workers) and 2.3 (Research & Development). On the other hand, 5.2 (Innovation linkages) and 3.2 (General infrastructure) contributions are the smallest.

As can be seen, in respect of innovation education-related variables matter mostly for the middle-income economies, for high income economies they are not so important.

Of course, taking into consideration for example data aggregation level, it is impossible to draw far-reaching conclusions. High income economies in the vast majority are already innovative, competitive, and modern, therefore education and tertiary education serve them as a solid foundation of their innovation. Shifts related to the Fourth Industrial Revolution (4IR) are already in progress in those countries, and that could partially explain the importance of R&D and knowledge creation. Middle income countries are at much lower socio-economic development stages, therefore education in general is more crucial for their innovation.

Table 3. *Multiple regression results for GTCI 2020 (HI, UMI and LMI economies)*

Dependent variable: GTCI 2020 (HI); Multiple R = 0.99999994; F = 198836E2							
R^2 = 0.99999988; df = 14.33; no. of cases: 48; Corrected R^2 = 0.99999983; p = 0.000000							
Standard estimation error: 0.004549658							
Absolute term: -0.002277175; Standard error: 0.0111074; t(33) = -0.205; p = 0.8388							
Variable	b* (value)	Partial correlation	Semi-partial correlation	Tolerance	R^2	t(33)	p
1.1	0.070	0.999858	0.020	0.086	0.914	340.488	0.00
1.2	0.055	0.999855	0.020	0.133	0.867	337.784	0.00
1.3	0.079	0.999889	0.023	0.085	0.915	385.428	0.00
2.1	0.113	0.999984	0.060	0.283	0.717	1001.422	0.00
2.2	0.086	0.999949	0.034	0.159	0.841	570.937	0.00
3.1	**0.071**	**0.999946**	**0.033**	**0.217**	**0.783**	**551.520**	**0.00**
3.2	**0.086**	**0.999891**	**0.023**	**0.074**	**0.926**	**389.423**	**0.00**
3.3	**0.072**	**0.999856**	**0.020**	**0.080**	**0.920**	**338.348**	**0.00**
4.1	0.123	0.999973	0.047	0.144	0.856	778.895	0.00
4.2	0.075	0.999972	0.046	0.371	0.629	762.708	0.00
5.1	**0.090**	**0.999983**	**0.059**	**0.420**	**0.580**	**976.361**	**0.00**
5.2	**0.126**	**0.999969**	**0.044**	**0.122**	**0.878**	**731.623**	**0.00**
6.1	**0.109**	**0.999977**	**0.050**	**0.214**	**0.786**	**841.290**	**0.00**
6.2	0.124	0.999979	0.053	0.184	0.816	887.693	0.00
Dependent variable: GTCI 2020 (UMI); Multiple R = 0.99999995; F = 138042E2							
R^2 = 0.99999989; df = 14.21; no. of cases: 36; Corrected R^2 = 0.99999982; p = 0.000000							
Standard estimation error: 0.002699426							
Absolute term: -0.001591148; Standard error: 0.0053482; t(21) = -0.2975; p = 0.7690							
Variable	b* (value)	Partial correlation	Semi-partial correlation	Tolerance	R^2	t(21)	p
1.1	0.097	0.999976	0.048	0.241	0.759	661.876	0.00
1.2	0.079	0.999968	0.041	0.272	0.728	574.242	0.00
1.3	0.100	0.999951	0.033	0.111	0.889	461.691	0.00
2.1	0.146	0.999991	0.077	0.281	0.719	1076.571	0.00
2.2	0.122	0.999988	0.067	0.298	0.702	929.875	0.00
3.1	**0.097**	**0.999978**	**0.049**	**0.258**	**0.742**	**686.909**	**0.00**
3.2	**0.102**	**0.999978**	**0.050**	**0.238**	**0.762**	**689.644**	**0.00**
3.3	**0.072**	**0.999965**	**0.040**	**0.301**	**0.699**	**550.130**	**0.00**
4.1	0.168	0.999990	0.074	0.195	0.805	1028.981	0.00

4.2	0.126	0.999991	0.078	0.379	0.621	1078.981	0.00
5.1	**0.165**	**0.999996**	**0.118**	**0.507**	**0.493**	**1638.211**	**0.00**
5.2	**0.169**	**0.999991**	**0.076**	**0.203**	**0.797**	**1059.488**	**0.00**
6.1	**0.129**	**0.999990**	**0.075**	**0.341**	**0.659**	**1044.941**	**0.00**
6.2	0.138	0.999988	0.067	0.235	0.765	927.777	0.00
Dependent variable: GTCI 2020 (LMI); Multiple R = 0.99999996; F = 137678E2							
R^2 = 0.99999991; df = 14.17; no. of cases: 32; Corrected R^2 = 0.99999984; p = 0.000000							
Standard estimation error: 0.002505810							
Absolute term: -0.006009384; Standard error: 0.0052659; t(17) = -1.141; p = 0.2696							
Variable	b* (value)	Partial correlation	Semi-partial correlation	Tolerance	R^2	t(17)	p
1.1	0.086	0.999973	0.040	0.222	0.778	561.366	0.00
1.2	0.060	0.999951	0.030	0.248	0.752	415.993	0.00
1.3	0.096	0.999981	0.048	0.245	0.755	661.701	0.00
2.1	0.107	0.999991	0.072	0.447	0.553	995.829	0.00
2.2	0.126	0.999991	0.070	0.313	0.687	975.049	0.00
3.1	**0.093**	**0.999988**	**0.060**	**0.421**	**0.579**	**835.088**	**0.00**
3.2	**0.097**	**0.999985**	**0.055**	**0.320**	**0.680**	**763.397**	**0.00**
3.3	**0.094**	**0.999965**	**0.036**	**0.145**	**0.855**	**494.449**	**0.00**
4.1	0.128	0.999987	0.058	0.204	0.796	798.773	0.00
4.2	0.172	0.999993	0.078	0.208	0.792	1087.716	0.00
5.1	**0.171**	**0.999995**	**0.090**	**0.275**	**0.725**	**1243.857**	**0.00**
5.2	**0.197**	**0.999994**	**0.086**	**0.190**	**0.810**	**1191.785**	**0.00**
6.1	**0.146**	**0.999992**	**0.074**	**0.255**	**0.745**	**1021.060**	**0.00**
6.2	0.143	0.999995	0.097	0.458	0.542	1341.469	0.00

Source: *Own calculations based on (Cornell University, INSEAD, and WIPO, 2019, p. 207; INSEAD, 2020, pp. 10-11; World Economic Forum, 2019, pp. 2-3).*

Education-related metrics play much more important role in GTCI 2020, what can be observed in Table 3. For high income countries (upper part) partial and semi-partial correlation coefficient values indicate that variables from the pillars Enable (1.1 and 1.3) and Grow (3.2 and 3.3) are the most significant to the model, while variables 4.2 and 5.1 (Lifestyle and Mid-level skills, respectively) have the least importance in terms of talent competitiveness. Again, formal education (3.1) is not so essential as lifelong learning (3.2) and access to growth opportunities (3.3), especially from the perspective of 4IR developments.

As concerns middle income economies (middle and lower parts of Table 3), partial and semi-partial correlation coefficient values indicate that variables 1.3, 4.1 and 5.2 (Business and Labor Landscape, Sustainability and Employability) for UMI economies and 3.3 and 5.2 (Access to Growth Opportunities and Employability) for LMI economies contribute to the created model to the greatest extent. Tolerance values for 5.1 (Mid-level skills) and 2.1, 3.1, 6.2 (External Openness, Formal Education, Talent Impact) are the highest, but not so high to justify removing them from the model.

Table 4. Multiple regression results for GCI 2019 (HI, UMI and LMI economies)

Dependent variable: GCI 2019 (HI); Multiple R = 0.99999457; F = 299484.4							
R^2 = 0.99998915; df = 12.39; no. of cases: 52; Corrected R^2 = 0.99998581; p = 0.000000							
Standard estimation error: 0.028402916							
Absolute term: 0.051791539; Standard error: 0.1139077; t(39) = 0.45468; p = 0.6519							
Variable	b* (value)	Partial correlation	Semi-partial correlation	Tolerance	R^2	t(39)	p
1st pillar	0.097	0.993329	0.028	0.086	0.914	53.796	0.000
2nd pillar	0.098	0.997198	0.044	0.203	0.797	83.244	0.000
3rd pillar	0.106	0.999101	0.078	0.540	0.460	147.173	0.000
4th pillar	0.105	0.999119	0.078	0.563	0.437	148.688	0.000
5th pillar	0.080	0.998363	0.058	0.512	0.488	109.021	0.000
6th pillar	**0.076**	**0.993000**	**0.028**	**0.132**	**0.868**	**52.504**	**0.000**
7th pillar	0.077	0.996333	0.038	0.249	0.751	72.724	0.000
8th pillar	0.083	0.995485	0.035	0.172	0.828	65.497	0.000
9th pillar	0.125	0.998536	0.061	0.236	0.764	115.301	0.000
10th pillar	0.188	0.999274	0.086	0.210	0.790	163.745	0.000
11th pillar	0.088	0.995683	0.035	0.162	0.838	66.990	0.000
12th pillar	0.173	0.997996	0.052	0.090	0.910	98.505	0.000
Dependent variable: GCI 2019 (UMI); Multiple R = 0.99999042; F = 108731.5							
R^2 = 0.99998084; df = 12.25; no. of cases: 38; Corrected R^2 = 0.99997164; p = 0.000000							
Standard estimation error: 0.033052137							
Absolute term: 0.096321166; Standard error: 0.0857921; t(25) = 1.1227; p = 0.2722							
Variable	b* (value)	Partial correlation	Semi-partial correlation	Tolerance	R^2	t(25)	p
1st pillar	0.104	0.993064	0.037	0.126	0.874	42.231	0.000
2nd pillar	0.099	0.995309	0.045	0.207	0.793	51.437	0.000
3rd pillar	0.134	0.998272	0.074	0.309	0.691	84.942	0.000
4th pillar	0.252	0.999514	0.140	0.311	0.689	160.261	0.000
5th pillar	0.135	0.998938	0.095	0.496	0.504	108.391	0.000
6th pillar	**0.077**	**0.992423**	**0.035**	**0.212**	**0.788**	**40.385**	**0.000**
7th pillar	0.087	0.995795	0.048	0.296	0.704	54.350	0.000
8th pillar	0.093	0.993661	0.039	0.174	0.826	44.195	0.000
9th pillar	0.136	0.997793	0.066	0.233	0.767	75.136	0.000
10th pillar	0.221	0.999144	0.106	0.228	0.772	120.764	0.000
11th pillar	0.116	0.996690	0.054	0.214	0.786	61.296	0.000
12th pillar	0.112	0.994850	0.043	0.146	0.854	49.077	0.000
Dependent variable: GCI 2019 (LMI); Multiple R = 0.99998981; F = 77663.51							
R^2 = 0.99997961; df = 12.19; no. of cases: 32; Corrected R^2 = 0.99996674; p = 0.000000							
Standard estimation error: 0.035579825							
Absolute term: -0.003120499; Standard error: 0.0821621; t(19) = -0.038; p = 0.9701							
Variable	b* (value)	Partial correlation	Semi-partial correlation	Tolerance	R^2	t(19)	p

1st pillar	0.083	0.995803	0.049	0.351	0.649	47.427	0.000
2nd pillar	0.149	0.997481	0.063	0.181	0.819	61.291	0.000
3rd pillar	0.146	0.998791	0.092	0.393	0.607	88.562	0.000
4th pillar	0.147	0.998855	0.094	0.410	0.590	91.017	0.000
5th pillar	0.210	0.999493	0.142	0.455	0.545	136.872	0.000
6th pillar	**0.118**	**0.997751**	**0.067**	**0.324**	**0.676**	**64.890**	**0.000**
7th pillar	0.073	0.993591	0.040	0.299	0.701	38.315	0.000
8th pillar	0.075	0.995982	0.050	0.446	0.554	48.476	0.000
9th pillar	0.115	0.996874	0.057	0.245	0.755	55.002	0.000
10th pillar	0.237	0.999134	0.108	0.210	0.790	104.677	0.000
11th pillar	0.107	0.997009	0.058	0.299	0.701	56.231	0.000
12th pillar	0.081	0.990542	0.033	0.161	0.839	31.468	0.000

Source: *Own calculations based on (Cornell University, INSEAD, and WIPO, 2019, p. 207; INSEAD, 2020, pp. 10-11; World Economic Forum, 2019, pp. 2-3).*

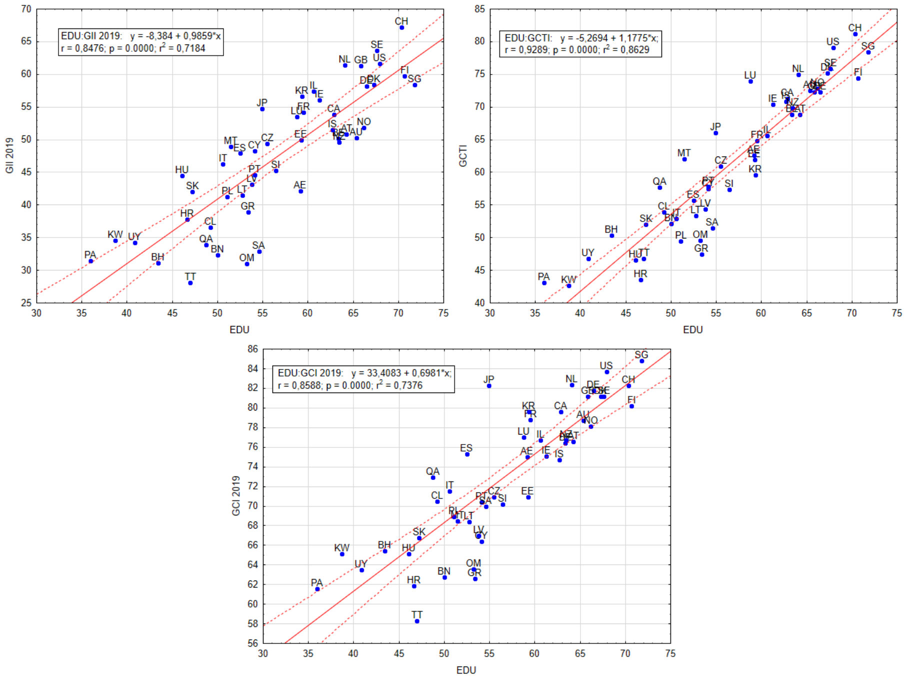
Multiple regression results for GCI 2019 presented in Table 4 can be treated as a further evidence of education importance in the context of competitiveness. For high income economies the most important competitiveness pillars are 1st, 6th and 12th (Institutions, Skills and Innovation capability), for upper middle economies – 1st, 8th and 12th (Institutions, Labor market and Innovation capability), and finally for lower middle economies – 2nd, 10th and 12th (Infrastructure, Market size and Innovation capability). It is worth emphasizing that innovation capability is among the most important areas for all income groups under scrutiny. The higher income group, the more important are institutions and skills (R^2 varies from 0.676 for LMI, 0.788 for UMI, and 0.868 for HI). Macroeconomic stability (4th pillar) and health (5th) seem to have the least importance in terms of competitiveness measured by GCI 2019.

4.2 Linear Regression Analysis Results

Due to partial unavailability of statistical data, what mostly concerned lower middle-income economies, suggested EDU index has been calculated for 109 countries – 48 high income, 35 upper middle income and 26 lower middle-income economies. Results of linear regression between EDU and GII, GTCI and GCI indices for those three income groupings have been presented in Figures 2 and 3.

In case of high-income countries Pearson correlation coefficient values are in the range of 0.85 (GII and GCI) to 0.93 (GCTI), which means strong relationship (with no visible outliers for 95% confidence limit). On the other hand, Pearson correlation coefficient values for upper middle-income economies vary between 0.60 and 0.75, whereas for lower middle-income economies – from 0,60 and 0.70. The relationship between EDU and global innovation and competitiveness indices is still quite strong, but scatterplots reveal some outliers, which can negatively influence correlation coefficient values for UMI and LMI countries, at least to a certain extent. Nevertheless, it can be stated that linear regression analysis confirmed the presence of quite strong relationship between EDU and indices under scrutiny. Although linear regression analysis has some methodological limitations (Armstrong, 2019), quite strong correlation between calculated education index and selected global indices can be observed. This is mainly true in case of high-income economies, but quite strong relationship is visible especially in upper middle-income group as well.

Figure 2. *Linear regression between calculated education index (EDU) and GII, GTCI and GCI – high income economies*



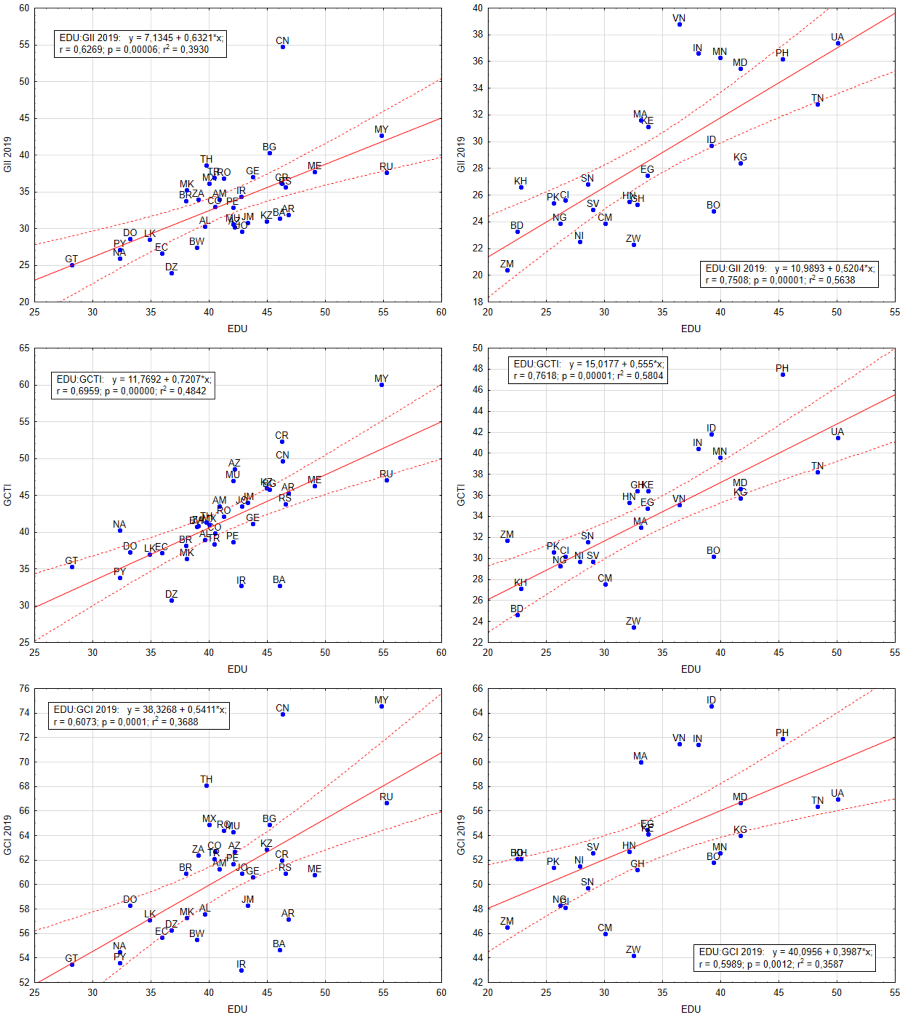
Source: *Own calculations based on (Cornell University, INSEAD, and WIPO, 2019, p. 207; INSEAD, 2020, pp. 10-11; World Economic Forum, 2019, pp. 2-3).*

5. Discussion and Conclusions

Comparison of global innovation and competitiveness frameworks shows that metrics related to the education area have been included to a large extent, especially in Global Talent Competitiveness Index. Their presence in the Global Innovation Index seems to be obvious, since human capital and its quality have a great significance for contemporary innovation models, including open innovation or reverse innovation. Predominance of education-related metrics in GTCI is also understandable, taking into consideration a growing importance of transnational corporations and other stakeholders in talent management processes.

Outcomes of multiple and partial regression analysis clearly confirmed that educational factor plays a crucial role in increasing innovation and competitiveness, what is particularly true in case of high-income economies. On the other hand, education advancements are also important for innovation and competitiveness of middle-income economies. High income economies are involved in building their innovation and competitiveness mostly on high qualified and skilled human resources making knowledge creation and absorption possible, thus middle-income economies must catch them up in many areas, like institutions, infrastructure, market sophistication and naturally education.

Figure 3. *Linear regression between calculated education index (EDU) and GII, GTCI and GCI – upper middle income (left part) and lower middle income (right part) economies*



Source: *Own calculations based on (Cornell University, INSEAD, and WIPO, 2019, p. 207; INSEAD, 2020, pp. 10-11; World Economic Forum, 2019, pp. 2-3).*

Results of linear regression analysis proved the existence of strong relationship between educational factor and selected global innovation and competitiveness indices. Lack of sufficient data had made the deeper research difficult or even impossible, especially when it would come to the comparisons and analyses based on long term data.

As mentioned earlier, the socio-economic literature on education, innovation and competitiveness and their interconnections is quite extensive. This study was aimed, most of all, to confirm the importance of education for innovation and competitiveness of given country groups, and in author's opinion that objective has been achieved. Moreover, it has been possible to demonstrate core distinctions between economy groupings when it comes to educational factor. In other words, higher education-related indices play crucial role in high income countries, while less sophisticated educational factors are more important for middle income countries. Finally, the calculated EDU index has proven its suitability, but certainly the conclusions could be much more accurate, if all level 2 sub-indices of GII, GCI, and GTCI have been included in conducted research.

Further analysis of interdependences between educational factor and innovation and competitiveness in a long run could be surely interesting, especially in post-pandemic era. For now, there are only speculations and unclear predictions, in what way coronavirus pandemic shall affect the global economy in years to come. Due to undoubted negative pandemic footprint global education sector will be among the most affected victims, but on the other hand education should play the key role in social, political, and economic post-pandemic recovery. Considerations in that matter are to be undertaken in author's forthcoming research.

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