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The Relationship between the Knowledge Economy and Global Competitiveness in the European Union

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Abstract: The main purpose of this paper is to study the influence of various indicators related to the knowledge economy on country competitiveness in the European Union (EU). Based on the Pearson coefficient and panel-data regression models, we analyzed the Global Competitiveness Index (GCI) in relation to research and development (R&D) expenditure (as a % of gross domestic product (GDP)), percentage of population with tertiary education, lifelong learning, GDP per capita, and debt to equity. The findings highlighted the crucial role of both innovation and education as determinants of EU competitiveness and economic convergence. The development of EU policies regarding the lifelong learning possibilities of the European workforce and the focus on research and development activities can significantly contribute to the competiveness of EU member states.

Keywords: competitiveness; knowledge economy; GDP; research and development; education; lifelong learning; correlation; panel data

1. Introduction

Global competitiveness has been one of the major goals of countries worldwide in the last few years, especially after the financial crisis emphasized the need for new strategies, innovations and dynamics in the economic and business environment. The Lisbon Strategy proved to be very difficult to implement and to reach a target of being the most competitive region in the world, but this objective has been reinforced on the European Union (EU) agenda and the Europe 2020 strategy.

Lately, the concept of competitiveness has become an essential factor in the assessment of countries and regions, especially due to its ability to create welfare and prosperity. In order to have pillars measuring the competitiveness of countries and, thus, a measurement method of the global competitiveness of countries, the World Economic Forum defined the Global Competitiveness Index (GCI). The World Economic Forum (2015) describes the GCI as a "set of institutions, policies and factors that determine the level of productivity of a country" and argues that productivity "is the main long-run engine for growth, living standards and prosperity" [1].

EU competitiveness has been analyzed by [2] using 25 indicators and grouped in the following categories: the ability to innovate; sustainability; the ability to export; business environment and entrepreneurship; public administration; finance and investments. Based on the World Competitiveness Yearbook, competitiveness is determined by four elements: economic performance, business efficiency, government efficiency and infrastructure. In other words, growth or economic performance is relevant for evaluating competitiveness but a number of other factors such as

environment, quality of life, technology, knowledge transfer, and scientific research could be more important. New methods of evaluation and scorecards underlying the knowledge economy or innovation factors have been used lately by the World Bank, the European Commission or the Organization for Economic Cooperation and Development (OECD) in order to rank competitiveness.

The role of education and training in economic competitiveness is an important priority for the EU as stipulated in its main documents: the Treaty of Rome (1957) and confirmed by the Treaty of Amsterdam and further by the Lisbon European Council, and was also stipulated in the strategy Education and Training 2020 (ET2020), which aims to improve the quality of lifelong and life-wide learning for strengthening creativity, innovation, and the potential for entrepreneurial skills [3] and to turn the EU into the most competitive economy worldwide [4].

The GCI, as mentioned, represents a defined indicator by the World Economic Forum to be able to compare the global competitiveness of countries. The global competitiveness indicator comprises three stages of country development, each with its sub-indexes indicating pillars of competitiveness, namely: the factor-driven stage (containing pillars of basic requirements: institutions, infrastructure, macroeconomic environment, health and primary education); the efficiency-driven stage (comprising pillars of efficiency enhancement: higher education and training, goods market efficiency, labor market efficiency, financial market development, technological readiness, market size); and the innovation-driven stage (including pillars of innovation and sophistication: business sophistication and research and development (R&D) innovation) [5]. These pillars are granted scores from 1 to 7 and these scores are aggregates to determine the overall global competitiveness index of countries. The relationship of the GCI index with other variables has been analyzed in previous studies, such as that by Petrylė which indicated a negative relationship between the GCI values of countries and the standard deviation of their gross domestic product (GDP) growth, revealing a tendency that higher GCI values indicate that those economies will grow steadier and will experience gentler fluctuations than the economies with lower GCI scores [6]. However, the study mentions the necessity of future research in order to determine the relationship of GCI with other variables, recommending future research in the field. Anton and Bostan [7] made another study regarding a panel dataset, where the role of access to finance in explaining cross-national differences in entrepreneurial activity across 25 EU members over the period between 2007 and 2013 was investigated, leading to a strong positive relationship between access to finance and total entrepreneurial activity. Thus, the studies in the GCI field can be explored further by new additions that also indicate their further dynamics and changes throughout time.

On the other hand, the knowledge economy is an economy where knowledge is acquired, created disseminated and used effectively to improve economic development [1]. The same authors underline the importance of knowledge, particularly in the case of developing economies, in order to improve the domestic economy, but also to be able to compete outside their borders through knowledge application in several fields, such as entrepreneurship, innovation, research and development. Powell and Snellman [8] confirm this definition of enhancing economic development through knowledge-intensive activities adding that the key components of a knowledge economy include a greater reliance on intellectual capabilities than on physical inputs or natural resources, combined with efforts to integrate improvements in every stage of the production process, from the R&D lab to the factory floor to the interface with customers. A knowledge-based economy is defined as 'an economy that is capable of knowledge production, dissemination and use: where knowledge is a key factor in growth, wealth creation and employment, and where human capital is the driver of creativity, innovation and generation of new ideas', with reliance on information and communication technology (ICT) as an enabler as mentioned by Cavusoglua [9].

A significant factor related to sustainable competitiveness and enhancing the knowledge economy is innovation, which is a pillar of progress in terms of knowledge and social, environmental and economic performance.

Regarding innovation, there are various perspectives on its meaning and importance for the economic environment. For example, Tanţău [10] mentions two types of approach for innovation, namely macroeconomic and microeconomic, as well as social and organizational. Păunescu [11] emphasizes that although innovation is viewed only from the economic perspective, it is providing more forms of value such as: social, environmental, moral and political.

Conclusions of relevant studies reflect that the sustainable competitiveness concept refers to quantifiable factors (e.g., level of GDP or GDP/capita, energy intensity, innovation indexes, inter-firm trading, patenting rates, labor supply and productivity, etc.) as well as to qualitative elements and conditions (e.g., informal knowledge, trust, social capital, quality of education and training, life quality etc.) confirmed also by [12]. Other authors have also analyzed the evolution of these indicators separately, such as energy intensity in the case of Cao and Qi [13], that have described the path of structural change in the history of energy intensity, but also the inverted-U development of economy-wide energy intensity or Belloumi and Alshehry [14], who analyzed the impact of urbanization on energy intensity for the case of Saudi Arabia.

The objective of the present study is to analyze the impact of GDP per capita, R&D expenditure as percentage of GDP, population by tertiary education attainment, gender and age, lifelong learning, debt to equity and the level of energy intensity on the global competiveness index of European economies, namely the dependent variable of the model, by estimating a panel data regression model. This can contribute to expanding the research regarding sustainability factors, including economic, environmental and social factors, on the GCI in recent years according to available data. The present study adds to the research in the field of the global competitiveness index by estimating the relationship between new variables and the GCI indicator, which have not been previously researched, thus, adding to the scientific literature in the field.

2. Conceptual Framework

Competitiveness and knowledge represent two key factors for enhancing long-term economic development, innovation and sustainability.

The theories defining competitiveness have been derived mostly throughout time from Adam Smith's international trade theories, being adapted as other influence factors arose over time and impacted competitiveness on company, regional or country levels. One general definition of competitiveness was provided by the OECD, namely "the ability of companies, industries, regions, nations or supranational regions to generate, while being and remaining exposed to international competition, relatively high factor income and factor employment levels on a sustainable basis" [15]. In this type of definition, competitiveness is described mainly with regard to financial outcomes.

In order to determine the global competitiveness of countries, the World Economic Forum defined the GCI as comprising 12 pillars, respectively: institutions, infrastructure, macroeconomic environment, health and primary education, higher education and training, goods market efficiency, labor market efficiency, financial market development, technological readiness, market size, business sophistication and R&D innovation [5].

To demonstrate the role of competitiveness in boosting EU member countries' economic growth, Voinescu and Moisoiu [16] used a comparison between the 12 pillars of competitiveness defined by the World Economic Forum and the 6 European Competitiveness factors. Their conclusions are that in the long-run, sustainability is the driver of competitiveness and economic growth in the EU and the key to becoming a top player in the knowledge economy is to invest in innovation and technology.

Also, Priede and Neuer [17] examined the competitiveness gap within the EU member states in the context of the Europe 2020 strategy which aims at delivering smart, sustainable and inclusive growth. The 12 pillars of the GCI have been used to measure competitiveness of the EU28 and 7 other countries. The countries analyzed show both positive and negative relations between investment in R&D and high-technology goods share in total export. In order to diminish the competitiveness gap,

they consider that countries have to increase commitment to smart growth by promoting investment in research and development.

Using factor analysis and cluster analysis, Stanickova [12] shows that significant disparity among member states weakens the EU28 competitiveness at the global stage based on regional and country competitiveness indexes. Conclusions of the paper reflect the fact that causes of competitiveness are usually attributed to the effects of aggregated factors rather than stand-alone factors.

Ciocanel and Pavalescu [18] studied the linear dependence between innovation and competitiveness for 29 European countries in the period 2008–2013 using performance evaluation models such as the Innovation Union Scorecard (IUS) and International Institute for Management Development (IMD) World Competitiveness Yearbook (WCI). The results were that innovation has a direct positive impact on competitiveness, thus increasing innovation that increases national competitiveness. Additionally, reducing innovation gaps can boost economic growth.

Regional competitiveness with a focus on Central and Eastern European (CEE) countries is another topic debated in the scientific literature. Sekuloska [19] investigates different foreign direct investment (FDI) inflows between two European regions and the influence on innovation (R&D in the business sector) using regression analysis. Her findings reflect the fact that stimulation of innovation through technology transfer is dependent on both the quality of FDI and R&D activities. Regional disparities in R&D levels are caused by quality and quantity disparities of FDI in those regions. Also, Molendowski [20] discusses the intra-industry competitiveness in the Visegrad Group countries using trade intensity based on the Grubel and Lloys Index. An important conclusion of the study is that changes in import and export values triggered by the crisis did not significantly affect trends of intra-industry trade. The crisis had more significant effects on the dynamics of intra-industry trade development of V-4 countries with regard to EU15 and EU10 countries. Bleotu [21] analyzed Romania's competitiveness evolution and trends against EU27 competitiveness, using the World Economic Forum's GCI. The author's conclusions are that there is a tendency of recovering the gap between Romania and EU27 and that Romania falls in the "stage 2—Efficiency driven" group as categorized by WEF.

Lower competitiveness of some developing EU countries is explained by various factors such as: the weakness of research systems, the weak connection between science and the economy, too little funding and supporting of innovation [22].

Loch, Chick and Huchzermeter [23] analyzed the factors driving European companies to competitiveness in the global arena. The role of governments, unions and education systems are considered relevant for this analysis. Progress occurs when businesses, governments and unions collaborate and educate the public, especially citizens unable to see the connection between competitiveness and unemployment. Also, Şipoş and Viaşu [24] demonstrated the positive and persistent causality of investment in education on economic growth.

The role of intellectual capital and education and labor market is underlined in various papers in relation to competitiveness and alternative ratios have been used to study the degree of the impact of different factors on a country' competitiveness. Using data from 40 developed, emerging and developing nations, Herciu and Ogrean [25] demonstrated that national wealth, national competitiveness and intellectual capital can lead to increased economic development.

Rozmahel, et al. [26] present an in-depth comparison and analysis to evaluate competitiveness within EU member countries. In order to assess competitiveness, the following indices were applied: labor productivity, nominal unit labor costs and real effective exchange rate (REER). For an alternative dimension of competitiveness evaluation to be established, two more indicators were selected, namely infrastructure and the quality of human capital, and a firm-level perspective on measuring country competitiveness was also been introduced. Using cluster analysis, the results show that from an infrastructure and human capital quality perspective, the CEE countries show slow and stable convergence.

Sabadie and Johansen [27] offer a view on how education and training contribute to national competitiveness using human capital and macroeconomic stability ratios. Their simulations show that countries which did not rank high can become competitive by implementing reforms to improve their human capital. At the same time, countries which currently rank high must retain and update their human capital. One of the constraints of their research is the limited list of indicators which do not cover all aspects of education and training. The better quality of human capital endowments would allow countries to gain high skill-intensive export competitiveness. The study of Ramoniene and Lanskoronskis [28] define higher education elements to be relevant to competitiveness: quantity and quality of both secondary education and tertiary education, funding of higher education, quality of research institutions and the higher education system link to labor and business sectors. The limitation of the study is finding similarities among higher education systems in order to find differences and similarities.

The paper of Stonkiene et al. [29] presents a model of analyzing competitiveness in higher education based on Porter's diamond model. Induction, deduction and comparison were used to research the subject. The article proposes a model for higher education system examination: factors that determine performance (human, financial, material, management, and leadership), the ability to measure the environment, and the introduction of internal changes (ability to compete on services and human resources). The conclusion is that "a high-quality higher education system which involves active participation of the public at large is a strong determinant to ensure the country development and international competitiveness". As a limitation, the method applied to measure the advantages of the performance is hindered both by the differences in higher education sectors of the states and by the fact that the education sector is a public responsibility.

Although well-educated human capital is indeed an important asset for the competitiveness of the EU, Begu and Vasilescu [30] have indicated that young people have anxious behavior, being worried about their success in the labor market. Even those with higher education worry that they will not find a long-term job or that they will have to move in order to find a satisfactory job.

Some researchers argue that making creativity a key priority in education reforms is critical in making Europe a sustainable and advanced knowledge economy.

Bratianu [31] mentions the increasing dynamics of change in knowledge management and in decision-making processes make knowledge dynamics significantly more important throughout time.

According to Vesela and Klimova [32], the knowledge economy is related to the creation, distribution and use of knowledge and information, which have replaced energy and capital as primary sources of wealth creation. Knowledge economies contributed to lifelong learning and investments in IT, research and education are crucial factors for economic development. One relevant factor, contributing to the expansion of knowledge and knowledge economy was the development in the information and technology sector, allowing rapid knowledge dissemination and decreasing costs of computers and technological resources over time, as emphasized by Hadzimustafa [33].

More specifically, according to Chen and Dahlman [34] the four pillars of the knowledge economy are:

1. An economic incentive and institutional regime that provides good economic policies and institutions that permit efficient mobilization and allocation of resources and stimulate creativity and incentives for the efficient creation, dissemination, and use of existing knowledge.
2. Educated and skilled workers who can continuously upgrade and adapt their skills to efficiently create and use knowledge.
3. An effective innovation system of firms, research centers, universities, consultants, and other organizations that can keep up with the knowledge revolution and tap into the growing stock of global knowledge and assimilate and adapt it to local needs.
4. A modern and adequate information infrastructure that can facilitate the effective communication, dissemination, and processing of information and knowledge.

Considering the new trends of Entrepreneurial Education and Training (EET) and Education for Sustainable Development (ESD), Sahlberg and Oldroyd [35] propose smarter pedagogies and innovation in teaching, despite large gaps in policy reformulation and the shortcomings of market-driven education. Bodirsky [36] examines the role of diversity of cultures as an asset for competitiveness, through studying EU documents and policy for the creative city of Berlin. Her research shows that the European citizen is increasingly defined through and by diversity and not through a "thick cultural belonging"—which gives Europe a strong cultural competitive advantage. The limitation of the study is that it has been researched only for one West European city, namely the capital city of Germany, and is not representative for the entire Union. However, a tendency of valuing diversity and using it as an asset is increasing in Europe and assists in growing the EU's competitiveness.

The issue of energy and its impact on EU competitiveness has become an essential aspect in the political debate lately, based on the EU strategic objective which is to ensure that its energy system contributes to EU competitiveness by providing consumption levels and prices that are competitive on a global level.

The findings of previous studies analyzing the relationship between energy intensity and competitiveness are mixed. Some of them [37,38] found a negative impact of some regulations influencing eco-innovations on national industrial competitiveness, other researchers found inconsistent results, and other papers results', such as Eichhammer and Walts [39], partially explained the energy efficiency influence on the competitiveness gap between developed and less developed countries.

Considering EU competitiveness, some authors Rennings and Rexhauser [40], using data from the European Community Survey, concluded that investment in energy-saving innovations could make a small contribution to competitiveness. On the contrary, the conclusions of the European Competitiveness Report 2012 demonstrate that energy-efficient products could significantly stimulate EU competitiveness. Other authors have also tested relationships between various indicators, such as determinants of environmental taxation on economic growth communities [41], have attempted to forecast the evolution of certain economic variables, such as the GDP of a country in the short term [42], or have measured the effectiveness of social media implementation at local government levels [43].

The European Competitiveness Report 2014 offers a more comprehensive analysis of the quantitative relationship between energy intensity and competitiveness based on panel data of countries and industries, providing more consistency and data relevance. The analysis provides evidence that export competitiveness is significantly related to energy intensity and energy is an important factor for EU competitiveness. Over the last few decades, technological improvement contributed to the decline of energy intensity and to a broad convergence of intensity levels in the EU, with major achievements being registered in the most intensive-energy countries of the EU.

3. Data and Methodology

For the empirical analysis, we selected one dependent variable, the GCI and 6 independent variables: R&D expenditure as a percentage of the GDP, tertiary education attainment (percentage of the population with tertiary education (levels 5–8), aged 15 to 64 years), lifelong learning (the percentage of people aged 18 to 64 who stated that they received education or training in the four weeks preceding the survey), GDP per capita, energy intensity (gross inland consumption of energy divided by GDP: kg of oil equivalent per 1000 EUR), and debt to equity (financial sector leverage, %) for the countries of the European Union (except Bulgaria and Luxembourg as they were acting like outliers in our analysis). Luxembourg had a very high GDP per capita compared to the other countries, mainly caused by the highly developed financial sector. Bulgaria had significant higher energy intensity due to the high percentage of heavy industry in the economy and was an outlier compared to other values of this indicator. In general, countries with an economy based mainly on services have a lower energy intensity, while economies based on heavy industry, like steel or iron

production, such as in the case of Bulgaria, are generally characterized by a high energy intensity and high energy consumption [30].

The GCI is formed of several pillars regarding social and economic aspects: institutions, infrastructure, the macroeconomic environment, health and primary education, higher education and training, goods market efficiency, labor market efficiency, financial market development, technological readiness, market size, business sophistication, innovation. The lifelong learning indicator and inflow of EU students were not included in the description of the GCI.

Expenditures for research and development cover basic research, applied research as well as experimental development, therefore fueling one of the most powerful engines of innovation. Research and development expenditure as a percentage of the GDP is the most commonly used measure of innovation, indicating the intensity of research and development of a country. R&D expenditure is an important enabling factor for human capital because it supports knowledge generation and skills development. On the other hand, highly skilled human resources are necessary for the EU's research and innovation capacity and competitiveness. Therefore, we cannot neglect the role of education, in particular tertiary education, in providing the necessary human capital for the knowledge-based economy. The indicator for lifelong learning is another aspect of knowledge, as lifelong education and training lead to new specializations and skills, thus indicating the human resources adaptation to change, in general, and to labor market demands, in particular. The dynamism of today's society requires great flexibility, creativity and adaptability of human resources to successfully deal with the most diverse tasks. GDP per capita reveals the accumulated productivity of the economy. As a measure of material prosperity, well-being, level of development, and so on, GDP per capita is usually linked to competitiveness, therefore it was a natural decision to include it in the analysis as part of the economic pillar. Energy intensity was selected due to the fact that it indicates the energy efficiency of a country. It contributes to economic prosperity in the context of low environmental impact, and in our analysis, it reflects the natural resources pillar of sustainable competitiveness. The debt-to-equity variable refers to the degree of the leverage of the financial sector of the economy. A high debt-to-equity ratio of the financial sector can have a strong positive effect on the global competitiveness of a country's economy. Debt-to-equity also measures the ease of credit and the ability of the country's economy to fund new innovations, thus also contributing to the competitiveness of the country.

The source of the data is the Eurostat database for the independent variables and the World Economic Forum for the GCI. The analyzed period was 2006–2015. We used SPSS and Stata statistical software to analyze the data and run the econometric models.

In order to examine the impact of the selected variables on the GCI, we estimated a panel data regression model with the following specification:

$$GCI_{it} = \alpha_i + X_{it} \times \beta + \varepsilon_{it} \qquad i = 1 \ldots N, t = 1 \ldots T$$

where X comprises the explanatory variables, the i subscript denotes the cross-sectional dimension (the country), and t denotes the time-series dimension (the year).

The factors estimated in the above model cover important aspects of sustainable competitiveness and the knowledge economy. As compared with previous studies, the model provides a new approach to estimate the key influencers on the competitiveness index of the EU economies.

4. Findings and Analysis

The first step of our analysis was to calculate the pairwise correlations matrix between the GCI and R&D expenditure as a percentage of GDP, tertiary education attainment, lifelong learning, GDP per capita, energy intensity, and debt-to-equity, indicators referring to the European Union countries (except for Bulgaria and Luxembourg) for the period 2006–2015, considering 260 observations. Table 1 summarizes the results, which are also available in Appendix A. The highest correlation is between the GCI and R&D expenditure as a % of GDP (0.8257), a result that indicates a very strong positive

relationship between innovation and competitiveness. High-income countries are usually the most competitive, an assertion that is also supported by our results: the correlation coefficient between GDP per capita and GCI (0.8099) indicates a strong direct link between these two variables. Lifelong learning is extremely important in the global changing economy and the countries that encourage and provide opportunities for education and training over the entire life cycle benefit from skilled human capital capable of generating added value, resulting in a more competitive economy; our results indicated a strong positive relationship between lifelong learning and GCI (0.7195). An average intensity relationship is between competitiveness and the share of higher education graduates, while the other analyzed variables are in a rather weak connection with GCI.

Table 1. Pairwise correlation matrix.

	GCI	RD (% GDP)	Tertiary_educ	Lifelong_Learning	GDP_Capita	Debt_to_Equity	Energy_int
GCI	1						
RD (% GDP)	0.8257	1					
Tertiary_educ	0.5472	0.4056	1				
Lifelong_learning	0.7195	0.7475	0.4821	1			
GDP_capita	0.8099	0.7007	0.5334	0.5508	1		
Debt_to_equity	−0.4466	−0.3581	−0.2876	−0.2843	−0.7385	1	
Energy_int	−0.26900	−0.2352	−0.1612	−0.1690	−0.2966	0.1366	1

* All coefficients are statistically significant at 0.05 level (see Appendix A). Source: Authors' calculation based on data from Eurostat and the World Economic Forum.

Because among some of the explanatory variables we observed medium or even strong correlations, we tested the multicollinearity (see Appendix B), but the results indicated that our model is not characterized by multicollinearity.

In Table 2 one can see the correlations between the GCI and the analyzed variables for the period 2006–2015 based on the Pearson coefficient.

The highest correlations were the ones between the GCI and the lifelong learning and GDP per capita, meaning that countries with a higher GDP per capita and more lifelong learning also have a higher GCI. As an example, in 2015 Denmark had the highest indicator of lifelong learning (37.4%) and a high GCI of 5.3 (rank 6 between the analyzed countries), while Sweden and Finland occupied the next two positions regarding the participation of adults in lifelong learning programs and ranks 4 and 3 regarding the GCI. Romania had the lowest indicator of lifelong learning (6.6%), which correlated with a lower GCI, rank 20 from the 26 analyzed countries World Economic Forum [44]. High values of GDP per capita are registered in 2015 in Ireland, Netherlands and Austria, countries in the top 10 regarding the global competitiveness index. Romania is once again on the last position with its value of GDP per capita. The evolution of the correlation between GDP per capita and GCI indicates that the importance of economic well-being in establishing international competitiveness was higher during the crisis and in the years immediately after.

Table 2. Correlations of global competitiveness index (GCI) with the analyzed variables for the period 2006–2015 based on the Pearson coefficient.

GCI Correlation with	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
debt to equity	−0.16	−0.12	−0.13	−0.32	−0.38	−0.34	−0.22	−0.35	−0.35	−0.39
gdp_capita	0.74	0.78	0.83	0.83	0.82	0.85	0.87	0.87	0.86	0.8
energy_intensity	−0.45	−0.49	−0.52	−0.5	−0.41	−0.46	−0.45	−0.41	−0.39	−0.41
life_learning	0.75	0.74	0.75	0.75	0.72	0.69	0.72	0.72	0.74	0.72
R&D	0.83	0.84	0.23	0.80	0.76	0.73	0.72	0.70	0.71	0.71
population_by_educ	0.67	0.61	0.23	0.61	0.56	0.56	0.54	0.54	0.56	0.55

Source: Authors' calculation based on data from Eurostat and World Economic Forum.

The GCI variable correlated strongly with the R&D expenditure (% of GDP). As one can observe in Table 2 the intensity of the correlation is high throughout the whole period 2006–2015. A moderate positive correlation can be observed between the GCI and the population by tertiary educational

attainment level, of the age group 15–64 years old, that signifies a higher global competitiveness index correlates with a higher level of the population attaining tertiary education in the EU. In 2015 the highest percentage of the population attaining tertiary education was registered in the UK 37.6%. Throughout the period 2006–2015, the tendency was that the percentage of the population in the EU countries obtaining tertiary education increased. Also, a low to medium correlation is observed between GCI and energy intensity, the strength of this relationship being on a downward trend. The negative Pearson coefficient between GCI and energy intensity indicates that countries with a high competitiveness index tend to have low levels of energy intensity, thus consuming less energy and being more efficient from the energy consumption point of view. For example, in 2015 countries with low energy intensity were Ireland, Denmark Malta and the United Kingdom, with values for this indicator under 100. Out of these four countries, only Malta has a lower value for the global competitiveness index (rank 19), the other three countries being in top 10. The country with the highest energy intensity in 2015 was Estonia (358) with a GCI of 4.74 that placed it on the 11th position between the analyzed countries. Romania also had high energy consumption with an energy intensity indicator of 226.7 and a low GCI of 4.3 according to Eurostat.

The lowest correlations were those between debt to equity of a country and the global competitiveness index, although in time the correlation between these two variables strengthened. In 2015, the last year of the analyzed period, low levels of debt to equity were registered in Malta, Ireland, Cyprus and Netherlands, whereas the countries with high values were Greece, Slovakia, Italy and the United Kingdom, indicating that the countries in the top 10 regarding the GCI can have either low or high values of debt to equity. The influence of this factor on GCI is very small, as results from the econometric analysis that we will describe hereafter.

In the econometric analysis we used the values expressed in logarithm for reducing the dimensionality of some of the variables, thus decreasing the risk that the errors would be heteroskedastic. We performed the unit root tests for our variables in order to check the stationarity (see Appendix C). The results indicated that only energy intensity is non-stationary and we decided to exclude it from our analysis.

Table 3 presents the results of the panel data estimations. First, we estimated a pooled ordinary least squares (OLS) model, the result being summarized in the first column. In Stata, when estimating such a model, the results also include a poolability test that has its null hypothesis the OLS model: $y_{it} = a + b^*X_{it} + \varepsilon_{it}$ and as its alternative the fixed effects (FE) model: $y_{it} = a + b^*X_{it} + \alpha_i + \varepsilon_{it}$. In other words, a poolability test can show if the FE model is more appropriate, that is, if the individual effects really matter. In our case, the output obtained indicated that the FE estimation is a better choice.

The next step was to estimate a FE model (column 2) and then a random effects (RE) model (column 3). The RE model implies full exogeneity of the model, a very strict assumption that we cannot claim for our data. Moreover, the results of the Hausman test indicated that the FE model is preferred in our case (see Appendix D 4).

Frequently, in the case of panel data models the errors are characterized by serial correlation. There is also the risk that the errors may be heteroskedastic. We tested both aspects: the *xtserial* test indicated that the errors are indeed correlated (see Appendix E) and the *xttest3* test suggested that the errors are heteroskedastic (see Appendix F). Therefore, we decided to estimate the model using the Driscol and Kraay method, robust estimation for serial correlation and heteroskedasticity, an approach that has also been used by Vasilescu [45] when analyzing youth unemployment in the EU countries using panel data models. The resulting model is summarized in the 4th column of Table 3. We added the values for R squared for the estimations in the table. Unfortunately, for the robust estimation, the value is no longer appropriate in a statistical sense. The variable debt-to-equity proved not to be statistically significant in the analysis.

The results of our econometric analysis indicated that research and development expenditure as percentage of GDP is an important determinant of the global competitiveness index: a 1% increase of R&D expenditure (as % of GDP) will lead to an increase of GCI by 0.054%, when all other variables

are constant. Innovation is generally seen as a driver of competitiveness because, by generating new ideas and technologies, it meets the development needs of the entire country. All domains benefit from research and development, either by identifying policies or good practices in the social and institutional area, by designing new products and services, or by developing new technologies for better use of resources and protecting the environment.

Lifelong learning also has a positive significant impact on the GCI, meaning that a higher percentage of adults included in training or education programs can stimulate the competitiveness of a country. The proportion of people aged 15 to 64 years with tertiary education is another determinant of the global competitiveness index, but it has a lower impact than lifelong learning, indicating that formal education has been overstepped. In this era of globalization and rapid change, lifelong learning is essential for the personal development of individuals and for their good integration into the labor market by responding to the specific needs of employers, aspects that increase the efficiency and competitiveness of an economy. In the long run, the benefits are numerous both at the individual level—the accumulation of knowledge and the development of new skills, as well as at the national level—a human resource capable of meeting market needs and adapting rapidly to new challenges is a vital element of competitiveness.

GDP per capita, as expected, has a positive influence on the global competitiveness index. Covering the economic dimension in our analysis, the result comes as a confirmation that a richer, more productive, economically efficient country has, of course, a competitive advantage.

Table 3. Summary of model estimations.

Model	(1) Pooled OLS	(2) Fixed Effects	(3) Random Effects	(4) Robust estimation (Driscoll-Kraay)
Dependent **Global Competitiveness Index (ln)**				
Independent				
R&D (% GDP) (ln)	0.0537353 *	−0.0365548 *	−0.0034541	0.0537353 *
Tertiary education (ln)	0.0219737 **	−0.030903 **	−0.0529583 *	0.0219737 *
Lifelong learning (ln)	0.0729984 *	−0.0059624	0.0284836 **	0.0729984 *
GDP per capita (ln)	0.1262163 *	0.1165509 *	0.1488918 *	0.1262163 *
Debt_to_equity (ln)	−0.0041562	−0.001503	−0.0016805	−0.0041562
Constant	−0.0194691	0.5040274 *	0.1451589	0.0194691
R-squared	0.7936	Within 0.236 Between 0.0072 Overall 0.0124	Within 0.1686 Between 0.5956 Overall 0.5698	-
No. of observations	260	260	260	260

The symbol * indicates that the coefficient is statistically significant at 0.01 level and ** indicates that the coefficient is statistically significant at 0.05 level. Source: Authors' own calculation.

Based on the regression analysis results, we can state that the purpose of enhancing competitiveness may also be achieved by focusing on the factors related to the knowledge economy: R&D expenditure as a percentage of the GDP, lifelong learning, and tertiary education attainment, therefore highlighting the importance of stimulating and developing the knowledge economy.

This study has, of course, some limitations. Our model is not an exhaustive analysis of the GCI that is influenced by other factors not included in the model, but a study of the influence of specific aspects regarding the knowledge economy on competitiveness. Another limitation is the endogeneity problem, which can occur in static panel data models. From a technical point of view, endogeneity may be addressed by using dynamic panel data. However, it is not the best choice in our case because the dependent variable is GCI—an aggregate indicator that is calculated each year for each country. It is obvious that a country with a good score has higher chances to also achieve good scores in the coming years. Still, we considered that a country's score in a year is not directly influenced by the score of previous years, but simply calculated on the basis of factors that compose the GCI. This is why we chose to use static panel data, for theoretical considerations.

5. Conclusions

The competitiveness of a country resides not only in the simple economic outputs, but also in the social, environmental, cultural elements and the appropriate combination of various factors. As reflected in the literature, the causes of competitiveness are usually attributed to the effects of an aggregate of factors rather than the impact of any individual factor [44].

Competitiveness represents an essential objective for every country. In order to achieve the Europe 2020 Strategy targets, the developed countries must permanently improve their "soft" dimensions, such as innovation, business sophistication, social cohesion, while developing countries must improve their "hard" pillars, on one hand, and their "soft" pillars, on the other hand [31]. In our analysis soft dimensions can be considered the R&D expenditure as a % of GDP, lifelong learning, and tertiary education attainment, while GDP, energy intensity and debt-to-equity could be described as hard pillars.

The empirical analysis indicated that some of the most important drivers of competitiveness are related to the knowledge economy: innovation and education. It is well known that innovation can generate smart growth by tackling specific issues in numerous domains. The creation and use of knowledge in economic activities generates higher value-added goods and services, thus increasing the chances of economic success in this competitive and globalized world economy. Technical progress, also a result of R&D activities, is a major source of productivity growth and of efficient environmental protection. We cannot neglect the innovation in the ICT field that has a significant contribution in the recent development of international markets.

A well-educated and skilled population is essential for the efficient creation, acquisition, and utilization of knowledge, emphasizing the benefits of innovation mentioned above. In our model both tertiary education and lifelong learning proved to enhance competitiveness, being crucial to the development of human capital, an indispensable resource for the competitiveness of a country.

Our results are of great interest for policy makers in the search for ways to increase the chances of the national economy to be globally competitive and to improve all aspects of sustainable development: economic prosperity, environmental issues and personal well-being. Emphasis should be placed on the development of lifelong learning models, as this system allows the creation, the acquisition and the application of knowledge, whereas the multitude of learning options and modalities, doubled by new pedagogical approaches, enhance the accumulation of new information and the development of practical skills. Also, the results support the need to stimulate innovation by allocating significant financial resources to research and development activities. R&D activities must become a priority on the agenda of policy makers because innovation, in the context of a well-developed knowledge economy, is an important determinant of a nation's competitiveness.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A.

	gci	RD_GDP	tert_e~c	life_l~g	gdp_ca~a	energy~y	debt_t~y
gci	1.0000						
RD_GDP	0.8257 0.0000	1.0000					
tert_educ	0.5472 0.0000	0.4056 0.0000	1.0000				
life_learn~g	0.7195 0.0000	0.7475 0.0000	0.4821 0.0000	1.0000			
gdp_capita	0.8099 0.0000	0.7007 0.0000	0.5334 0.0000	0.5508 0.0000	1.0000		
energy_int~y	-0.4466 0.0000	-0.3581 0.0000	-0.2876 0.0000	-0.2843 0.0000	-0.7385 0.0000	1.0000	
debt_to_eq~y	-0.2690 0.0000	-0.2352 0.0001	-0.1612 0.0092	-0.1690 0.0063	-0.2966 0.0000	0.1366 0.0276	1.0000

Figure A1. Pairwise correlation matrix of the selected variables (global competitiveness index (GCI), research and development (R&D) expenditure as percentage of GDP (RD_GDP), lifelong learning (life_learn'g), tertiary education (tert_educ), GDP per capita (gdp_capita), energy intensity (energy_int'y), debt to equity (debt_to_eq'y)).

Appendix B.

Variable	VIF	1/VIF
ln_RD	3.16	0.316795
ln_gdp_c	2.63	0.380031
ln_life_l	2.48	0.403670
ln_tert_educ	1.60	0.625624
ln_de	1.13	0.883479
Mean VIF	2.20	

Figure A2. Test for multicollinearity for the selected variables (R&D expenditure as percentage of GDP (RD_GDP), lifelong learning (life_learn'g), tertiary education (tert_educ), GDP per capita (gdp_capita), debt to equity (debt_to_eq'y)).

Appendix C.

Table A1. Unit root tests for the selected variables (global competitiveness index (GCI), tertiary education (tert_educ), R&D expenditure as percentage of GDP (RD), lifelong learning (life_l), GDP per capita (gdp_c), debt to equity (de), energy intensity (energy_int)).

Panel Unit Root Test: Levin-Lin-Chu Test			
	adj. t-statistic	unadj. t-statistic	*p*-Value
ln_gci	−5.5651	−10.4354	0.0000
ln_tert_educ	−6.3214	−6.9081	0.0000
ln_RD	−4.9795	−6.9779	0.0000
ln_life_1	−8.0365	−10.0931	0.0000
ln_gdp_c	−1.4412	−4.3224	0.0748
ln_de	−10.6151	−13.3314	0.0000
ln_energy_int	1.776	−1.5186	0.9621

Appendix D.

```
                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |       f            r          Difference          S.E.
-------------+----------------------------------------------------------------
       ln_RD |   -.0365548    -.0034541       -.0331007        .0022573
ln_tert_educ |    -.030903    -.0529583        .0220553        .0005827
   ln_life_l |   -.0059624     .0284836        -.034446               .
    ln_gdp_c |    .1165509     .1488918       -.0323409               .
       ln_de |    -.001503    -.0016805        .0001776               .
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(5) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =       69.08
                Prob>chi2 =      0.0000
                (V_b-V_B is not positive definite)
```

Figure A3. Hausman test (R&D expenditure as percentage of GDP (RD), lifelong learning (life_l), tertiary education (tert_educ), GDP per capita (gdp_c), debt to equity (de)).

Appendix E.

```
Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
    F(  1,      25) =    114.915
           Prob > F =      0.0000
```

Figure A4. Test for autocorrelation in panel data.

Appendix F.

```
Modified Wald test for groupwise heteroskedasticity
in fixed effect regression model

H0: sigma(i)^2 = sigma^2 for all i

chi2 (26)  =    1101.36
Prob>chi2 =      0.0000
```

Figure A5. Test for heteroskedasticity.

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