Abstract: In today’s turbulent world influenced by globalization, knowledge is becoming a key factor in the market. Every economy, if it wants to be successful and competitive, must pay more attention to knowledge and its creation, transfer, and preservation. In this respect, it is a key element in ensuring a country's sustainable position in a competitive environment. Based on this, we set out the main idea of the article as follows: increased emphasis on the factors of a knowledge-based economy affects the growth of the country’s competitiveness, which contributes to its better sustainability. To verify the idea, we used a multi-criteria evaluation of countries by the TOPSIS method and a subsequent regression model. We examined developments in the EU countries over a period of 11 years in selected indicators typical for the knowledge economies, in the area of competitiveness. Finally, we examined the sustainability of EU countries. Based on the findings of these methods, we identified the leading country—Sweden—in the field of knowledge economy, competitiveness, and sustainability.

Keywords: knowledge economy; economic growth; competitiveness; sustainable development; Europe 2020

1. Introduction

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. Competitiveness, knowledge, and research and development are the priorities of every country today. However, more than the current position of the country, it is necessary to take into account the long-term sustainability of these areas to build a strong and sustainable economy.

In today's world, sustainability issues are becoming increasingly urgent. Among the different approaches to defining this concept, a common attribute is future orientation. The economy of sustainability is usually based on the idea of resource efficiency. As a sustainable economy is about a long-term future, which is largely unknown, questions about the knowledge that can ensure the country’s long-term stability and growth need to be answered.

The knowledge economy is not just a new theoretical concept, but a new epoch, which has a fundamental difference from the era of agrarian and industrial economies. Although it appeared only in the early 1990s, it has already had an impact and caused changes in all spheres of economic and social life, and this influence is constantly growing. The trend of development of a knowledge economy is the formation of a knowledge economy, which will mean the onset of a new stage in the development of the global economy [1]. The idea of a knowledge-based economy dates to the 1990s. Its primary objective was for European countries to catch up with America in technological development. Many theories
have emerged that determine the direction of European countries [2]. The issues of sustainable 
development and the knowledge economy are two directions of development to which most countries 
of the world, including EU Member States, draw attention. Countries face constant changes in 
scientific and technical development, but there are also new modern trends in the way they do business. 
Every participant in this global market is forced to adapt its activities to these rapid changes. Countries 
strive to increase their level of development depending on the available resources. Resources are a 
means of achieving development, but, as most resources are limited, they should also be used in the 
context of meeting the needs of future generations. In most countries today, the process of sustainable 
development is well in line with the process of developing the knowledge economy. To achieve the 
appropriate changes, the two processes need to be harmonized [3]. The knowledge economy is often 
explained as a possible way to transform society to achieve sustainable economic growth as well as 
to solve the various climate challenges arising from the growing scarcity of resources [4]. Based on 
this, the main idea of the article is to increase the emphasis on factors related to a knowledge-based 
economy that affect the growth of the country’s competitiveness, which contributes to its improved 
sustainability. The attention is focused on the mutual influences and overall impacts on the country of 
these main research areas: knowledge-based economy, competitiveness, and sustainability.

2. Literature Review and Conceptual Framework

The concept of sustainable development is rather dynamic. This means that this issue can be 
described from several perspectives [5]. From the point of view of most theoretical approaches, 
the issue of sustainable development distinguishes three components: environmental, economic, 
and social. Of these three aspects, so far, the environmental dimension of sustainability has received 
the most attention. If people want to live in a prosperous country with a healthy environment, it is 
necessary to address the major trends of today’s world (such as changing demographics, changing 
consumer patterns, social change, changes in the use of natural resources, and growing pressure 
on natural resources and ecosystems) that may worsen the situation. However, the importance of 
the economic dimension of sustainability is also undeniable in today’s globalized world; therefore, 
this document is focused on the economic component of sustainability. In particular, the economic 
aspect of sustainability addresses the issue of the development of performance as well as the standard 
of living. Improving sustainability performance can affect a country’s competitiveness. It is therefore 
necessary to ensure not only suitable conditions but also suitable resources for sustainable economic 
growth. Education, an educated population, and knowledge are likely to lead to the availability of 
appropriate resources in the future. Many studies show that the transition to a knowledge-based 
economy through the introduction of innovation significantly increases a country’s performance as 
well as living standards. Innovations are an important determinant of sustainable competitiveness 
and the growth of the knowledge economy. They are a fundamental factor in progress in the social, 
environmental, and economic fields [6]. The way in which individual economies respond to these 
challenges also has a major impact on their sustainable growth and position in the world’s economy. 
In an effort to better understand the relationships among sustainability, competitiveness, and the 
knowledge economy, a conceptual framework was also defined for our research. EU countries clearly 
defined their approach to this issue in the Europe 2020 strategy, one of the objectives of which is to 
achieve a sustainable future and sustainable growth. The question remains as to how successfully 
individual EU countries are achieving this convergence. From a conceptual point of view, this work 
seeks to explain and examine the interrelationship of the impact of the knowledge economy on the 
competitiveness of the economy, which is reflected in the economic dimension of achieving results for 
sustainability in individual EU countries. However, it should be noted that the achievement of the 
sustainable development goals of individual countries must be fulfilled in the context of the necessary 
interconnections among all three dimensions in order to achieve balance.

Sustainable development is a widely defined term without an exact or strict definition. Sinakou [5], 
Hanushek [7], Širá et al. [8], Valliere and Peterson [9], Busu and Trica [10], and Kiseľáková et al. [11]
identified indicators that are suitable for quantifying economic growth (e.g., GDP, inflation, unemployment, productivity, government departments, and circular economies), but the next important indicator to identify the economic growth in today’s world is knowledge. From this view, we can argue that development would be limited if knowledge support were limited. However, creating new knowledge is not expensive, but, in most cases, it takes effort and time [12]. Other studies devoted to the sustainability of the knowledge economy include those by Ocak and Findik [13], Cantu-Martinez [14], Mikalauskiene and Atkociciene [15], Li et al. [16], Chang et al. [17], and Melnikas [18].

For a more accurate understanding of the term “knowledge economy”, it is necessary to become acquainted with several approaches to it (Durazzi [19]; Saridogan and Kaya [20]; Sagiyeval et al. [21]; Milewska [22]; Ayan and Pabuccu [23]). There is no single approach or clear concept for defining the term “knowledge economy”. The OECD defines knowledge-based economies at a very general level as those that are directly based on the production, distribution, and use of knowledge and information [24]. The knowledge economy can be defined, in one respect, as a way of creating a product based on activities dependent on knowledge and expertise that contribute to the creation of scientific and technological progress. The fundamental determinants of the knowledge economy include a more significant ratio for the dependence of the economy on intellectual abilities than on physical inputs or natural resources in the context of the integration of new knowledge at each level of the production process [25]. The knowledge economy is developing on the basis of two driving forces. The first is the increasing knowledge level of economic operations and the second is the globalization of economic events [26]. According to Dudová [27], the prerequisites for the emergence of knowledge economies include the long-term tendency of a gradual increase in the weight of intangible capital on production factors and the emergence and growth of the diffusion of information and communication technologies. Changes in countries towards the transition to the level of knowledge economy are considered a new trend in the global environment. This transformation has become a necessity, especially for emerging economies, which suffer from a low degree of economic competitiveness. It should be noted, however, that these changes require a clear and effective policy-making approach that responds, in particular, to the needs of these countries and their available resources [28].

According to Milewska [22], achievement of a knowledge-based economy requires a transition from a material perception of the economy to one that exploits innovation potential, human capital, knowledge, and new technologies. The intellectual potential, supported by the constant development of people and the appropriate skills of the workforce, as well as the growing competition in the field of innovation, significantly influences the sustainable development of today’s economies. Ayan and Pabuccu [23] argued that the knowledge economy is an economy that invests more in quality information than capital inputs, which is an important determinant for economic development and increased competitiveness. The speed of dissemination of new and current knowledge is an important factor in economic development. This is also confirmed by the fact that the most dynamic and competitive countries in the world have economies that make large investments in information factors. Lüthi et al. [29] defined knowledge economy as a type of economy in which there is a strategic combination of highly specialized knowledge and skills at different stages of the value chain in the context of maintaining a competitive advantage. According to Sagiyeval et al. [21], the knowledge economy participates in the creation of new resources and artificial intelligence and their implementation in all sectors of the national economy in order to substitute natural resources and human intellect. The creation of such a knowledge environment is caused by the introduction of new technologies in an effort to save resources but also by the development of extensive knowledge of new technologies and skills. Collison and Parcel [30] showed the three pillars of the knowledge economy (Figure 1). The first pillar contains people who are willing to learn and share knowledge. The second pillar is the information infrastructure that enables the exchange of knowledge. The third pillar contains processes that facilitate sharing, codification, and knowledge discovery.
In terms of the knowledge economy, the key term is knowledge. Knowledge is a complex term that attracts the attention of both theorists and the practical sphere. Various approaches have been developed [38], but the only thing that seems to be common is the idea that knowledge is more than just data and information itself [39]. Knowledge is sometimes considered as the fifth factor of production in the current economy, and it plays a critical role in economic performance [40]. However, it is indisputable that the knowledge economy is built on knowledge, which is its main capital. The actual functioning of the economy is based on the production of information and knowledge as goods [41]. Knowledge management is important, because knowledge is one of the most strategic means that can lead to sustained increases in profitability [42]. It is important for a knowledge society [43].

According to Rim et al. [44], in today’s highly competitive environment, it is necessary to assess the level of actual development in the management of the knowledge economy and to take measures to support and grow accordingly. For this reason, it is essential to identify the key indicators entering...
into the evaluation in order to subsequently improve the evaluation methodology. To talk about the knowledge economy without being able to measure and evaluate its influence would not be of great utility. Many indicators have been gradually developed to capture these manifestations and impacts. In this section, we introduce some of them and explain their nature and how they are interpreted.

Based on certain similar features, we can divide the indicators of the knowledge economy into two categories. The first category focuses on the basic characteristics of the knowledge economy, and this group of indicators describes the share of the knowledge economy in the whole economy of the country, e.g., the proportion of people working in high-tech industries, or the proportion of people with higher education. In the context of information economy, universities become powerful centers that both consolidate strong intellectual capital and generate new knowledge and technological innovation in their research activities [45]. The second large group consists of the so-called performance or output indicators. These include, among others, the production of high-tech industries, high-tech exports, GDP growth, and labor productivity growth [46].

Let us mention another approach to the classification of indicators. For example, instead of indicators based on the characteristics of the knowledge-based economy, the World Bank talks about the pillars of the knowledge-based economy. It defines four basic pillars:

• a supportive economic and institutional mechanism that provides an incentive scheme to make better use of existing information and generate new knowledge in business;
• an educated and qualified population that generates and uses new knowledge;
• a dynamic information infrastructure for the communication, dissemination, and processing of information; and
• an effective system of innovation for businesses, research centers, and universities to generate new knowledge [32,47].

Roberts [48] divided the knowledge economy indicators into four groups:

• indicators based on innovation and entrepreneurship total R&D expenditure by industry, enterprise R&D expenditure by size of enterprise, and the number of scientific and technical publications per capita;
• indicators based on human capital;
• indicators based on information and communication technologies; and
• indicators based on economic and social impacts.

Human capital is a part of intellectual capital that is not owned by the organization but by the employees themselves. In the environment of the knowledge economy, human capital is defined by the skills of employees, their talent, and their knowledge [49]. The development of a knowledge-based society and a sustainable economy depends considerably on the ability to produce competitive goods and services and to distribute them in the global market. Global economic activity changes fast and heavily impacts the competitive possibilities of developing countries; it is not easy to achieve or to save competitiveness. It is not enough to only be passively open for the free market [50].

2.2. Impact of the Knowledge Economy on the Competitiveness of EU Countries

The current global business environment is shaped by the transition to a knowledge economy, which has moved the competitiveness of business activities to a completely different level. As the issue of the knowledge economy is a fundamental determinant of the economic development of individual economies, its level is considered to be an important indicator in the context of comparing world economies [51]. According to Gorokhova [52], the ability to generate and absorb knowledge and use it effectively helps to create innovations, achieve competitive advantages and economic efficiency, and produce human capital, and in turn determines the effectiveness of economic development. The issue of competitiveness from the perspective of the knowledge economy was analyzed by
The problem of competitiveness in the world economic space is extremely important for any country, especially in the context of globalization of the world economy, where the importance of various forms of external economic relations and the degree of openness of national economies to foreign products, services, and capital are growing sharply [58, 59]. Šterbová et al. [60] stated that competitiveness can be understood as a comparative view of the subject and its ability to sell and offer goods and services in a given market. The authors added that attention is paid mainly to the external aspects of the performance of countries or the whole region. The importance of competitiveness has been addressed over the course of history by a number of economists, with a number of independent definitions of competitiveness arising. One of the first is the approach of Scott and Lodge [61], who characterized competitiveness as the ability of the country to produce and distribute products or services in an international environment for profit. According to Štefko [62], competitiveness can be understood as the ability of a company, industry, or country to compete, to lose business interests with leading companies or countries, and to secure at least medium-term prosperity, with the aim of achieving sustainable, long-term prosperity. In this definition, the author placed emphasis mainly on the future, i.e., medium term, and eventually long-term sustainable prosperity as a result of the company’s competitive position.

Measurement of competitiveness can be approached from several points of view. The Global Competitiveness Index (GCI) published annually by the World Economic Forum is also used to assess the country’s competitiveness. For more than three decades, the World Economic Forum has been an institution concerned with the area of competitiveness and its quantification. Annual reports on global competitiveness compare many factors in the area of national competitiveness. In the case of the Global Competitiveness Index (GCI), several indicators are included in the observation due to the complexity of the outputs in the assessment of this area. The GCI currently comprises 114 indicators divided into 12 pillars. The area of innovation is included in the 12th pillar of the GCI [63].

Maintaining global competitiveness has been one of the main challenges facing countries around the world in recent years. At first, the countries of the European Union sought to achieve this goal through the implementation of the Lisbon Strategy. However, this proved to be very challenging, and, therefore, this goal was subsequently strengthened in the Europe 2020 strategy [6]. The Europe 2020 strategy also aims to improve sustainable growth, environmental protection, and social cohesion [64]. This strategy confirms that the European Union wants to achieve the sustainable development of the EU countries’ economies. There are three priorities of Europe 2020:

- smart growth, which is based on the development of the economy using knowledge and innovation;
- sustainable growth, through more efficient use of resources; and
- inclusive growth that supports a high-employment economy with consequent economic, social, and territorial cohesion [65].

3. Materials and Methods

Every economy, if it wants to be successful and competitive, must pay more attention to knowledge and its creation, transfer, and preservation. In this respect, the knowledge is a basic component in ensuring the country’s sustainable position in a competitive environment. Competitiveness is in today’s world a very important part of every country. It represents the position of the country’s rank among other countries. However, in this case, it is very important to gain the appropriate competitive level for a long time, so as to build a sustainable economy. Based on this, we set out the main idea of the article as follows: we increase the emphasis on the factors of a knowledge-based economy affecting the growth of the country’s competitiveness, which contributes to its improved sustainability. The attention is focused on these main research areas, their interconnections, and their interactions. The research is based on the evaluation of the relationships between them, as shown in Figure 2.
When selecting the indicators of the knowledge economy, we were inspired by a team of authors [45], who used these indicators as a basis for the research index. Furthermore, in the works of Batagan [69] and Arundel et al. [46], these indicators are also used as the main indicators assessing the knowledge economy.

The secondary objectives are to determine how the selected indicators of the knowledge economy affect the country’s competitiveness in their interaction and whether competitiveness affects the sustainability of the economy. This was realized by the statistical evaluation of the following hypotheses.

**Hypothesis 1.** There are statistically significant differences in the comprehensive assessment of the competitiveness of EU countries using the CV (Coefficient of Variance)–TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) technique.

The area of competitiveness was quantified according to the overall outputs of the TOPSIS technique. The CV–TOPSIS inputs were as follows:

- tertiary education as a percent of population;
- Research and Development (R&D) expenditure as a percent of gross domestic product;
- total amount of patents per million population; and
- score in the 12th pillar of the GCI.

The second hypothesis was established on the basis of proven differences between individual countries.

**Hypothesis 2.** There is a statistically significant positive dependence of competitiveness (12th GCI pillar) on the knowledge economy of individual EU countries.

The positive dependence is based on the fact that, when better outputs are achieved in indicators of a country’s knowledge economy, its position in the 12th GCI pillar also improves. When formulating the hypothesis, we started from already conducted research by several authors. Schiuma et al. [66] demonstrated the impact of knowledge in the company on its performance. Kianto et al. [67] validated the positive effect of knowledge on competitiveness. Krstić and Stanišić [68] also validated the positive effect of knowledge on competitiveness at country level.

We evaluated the level of the knowledge economy according to selected indicators:

- tertiary education as a percent of population;
- R&D expenditure as a percent of gross domestic product; and
- total amount of patents per million population.

The form of reporting these indicators was chosen for a better comparability of countries. When selecting the indicators of the knowledge economy, we were inspired by a team of authors [45], who used these indicators as a basis for the research index. Furthermore, in the works of Batagan [69] and Arundel et al. [46], these indicators are also used as the main indicators assessing the knowledge economy.

It was also necessary to examine the values of competitiveness. This is very specific area with different meanings and interpretations; thus, to make the relevant analysis and conclusions, we needed...
to quantify it. We chose the World Economic Forum’s approach to assess and quantify the country’s competitiveness through the GCI. We found the WE Forum approach to be the best for quantification. It was chosen for the reasons given below:

- This institution has been dedicated to competitiveness and its measurement and quantification for over 40 years.
- They publish the ranking regularly (every year).
- This institution compares countries from all over the world.
- The approach has been used by other authors [6,50,54,59,68].

This approach has some advantages and some disadvantages. We mention the positive aspects above. A disadvantage of this method is the data and methodology used. GCI materials rely heavily on data collected from surveys and have complex weighted value systems in terms of technology, public agencies, and the macroeconomic environment. One-third of the data are statistical data and two-thirds are obtained on the basis of a questionnaire.

The overall GCI value is influenced by the partial score values obtained in each assessment area. In the GCI, we therefore focused our attention on the 12th pillar, which assessed innovation. Within this pillar, we considered country scores. Based on the above, this hypothesis can be built in various variants and thus as follows:

**Hypothesis 2A.** There is a statistically positive dependence of competitiveness (12th GCI pillar) on the level of tertiary education.

**Hypothesis 2B.** There is a statistically positive dependence of competitiveness (12th GCI pillar) on spending on science and research.

**Hypothesis 2C.** There is a statistically positive dependence of competitiveness (12th GCI pillar) on the number of patents.

Based on the assumed differences at the country level, the third and final research hypothesis was set out as follows.

**Hypothesis 3.** There are statistically significant differences between dependence of competitiveness (12th GCI pillar) on knowledge economy at the level of individual EU 28.

The economic dimension of the sustainability of the overall development of the EU community, as one minor goal of this article, is emphasized by the Europe 2020 strategy. We only analyzed the economic dimension of sustainability, because of the penetration of this area with knowledge economy and competitiveness—our main research areas. This strategy has set priorities and targets that EU countries are scheduled to meet by 2020, which also covers our research period. For this reason, this strategy was chosen as a comparable factor to investigate the sustainability in the period under review and in the conditions valid for EU countries. Moreover, one of the priority objectives of this strategy is that of the aim we are investigating: “The aim of the Europe 2020 in the field of knowledge and innovation is to reach the expenditures on R&D as 3% of gross domestic product for the EU countries” [65].

As a sample of countries, we chose the countries forming the EU. The selection was also conditioned by the commitment of the EU 28 to the Europe 2020 strategy. The current contribution also includes the United Kingdom within the EU, as we evaluated the period of 11 years, i.e., from 2007 to 2017. To verify the idea, we used a multi-criteria evaluation of countries by the TOPSIS method and a subsequent regression model. We evaluated the development of these countries in the given years as well as the structure of the evaluation of overall results in specific countries.
The above objectives and hypotheses were fulfilled and evaluated using several mathematical–statistical methods. The above-mentioned TOPSIS method was chosen as the main tool for assessing “countries’ competitiveness” as one value for evaluating the level of each monitored area. The perception of the advantages and disadvantages of this method differs due to their use in different situations and contexts. Following a comparison with other relevant methods (AHP, ELECTRE, etc.), Shih et al. [70] outlined the following advantages of the TOPSIS method: the logic representing the rationality of human choice, the general value which takes into account the best and worst values of the criteria, the use of a simple calculation that can be easily programmed, and the alternative results which can be illustrated by a polyhedron (minimum two dimensions). Bhutia and Phipon [71] also added the advantages of easy use, the ability to work with all types of criteria (subjective and objective), and rationality and understanding. Kandakoglu et al. [72] and Shih et al. [70] considered the absence of the possibility of allocating weights to the criteria and the lack of consistent control by the decision maker as the main disadvantages of the TOPSIS method. For this reason, we chose the Coefficient of Variance as a suitable method for this kind of processing (as applied by Vavrek and Chovancová [73]).

Our team of authors has rich experience with this method [74–76].

According to Zavadskas et al. [77], this technique can be considered one of the most frequently used MCDM (Multi Criteria Decision Making) methods (for more details, see [78,79]). The result could be characterized as a solution with the shortest distance to a positive ideal solution (PIS) calculated using the Euclidean distance [80]. The TOPSIS technique offers a solution that is closest to the above-mentioned PIS and also furthest from the negative ideal solution at the same time [81]. Moreover, Carayannis et al. [82] studied this method with respect to the specifics of the knowledge-based economy. He focused on the development and methodological characteristics within the MCDA that are influenced by a given area of interest.

The individual steps of the TOPSIS technique were developed by Vavrek et al. [74], and these characterize the next sequence of this method:

(a) Build the criterion matrix, which represents the ranking of possibilities in accordance with the set characteristics:

\[
D = \begin{bmatrix}
X_1 & X_2 & \cdots & X_j & \cdots & X_n \\
A_1 & x_{11} & x_{12} & \cdots & x_{ij} & \cdots & x_{1n} \\
A_2 & x_{21} & x_{22} & \cdots & x_{2j} & \cdots & x_{2n} \\
\vdots & \vdots & \vdots & \ddots & \vdots & \ddots & \vdots \\
A_i & x_{i1} & x_{i2} & \cdots & x_{ij} & \cdots & x_{in} \\
\vdots & \vdots & \vdots & \ddots & \vdots & \ddots & \vdots \\
A_m & x_{m1} & x_{m2} & \cdots & x_{mj} & \cdots & x_{mn}
\end{bmatrix}
\] (1)

where \(A_i\) is the \(i\)th alternative and \(X_{ij}\) is the value of the \(j\)th parameter achieved by the \(i\)th alternative.

(b) Build the normalized criterion matrix. To get this matrix, calculate the next formula:

\[
r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{j=1}^{n} x_{ij}^2}}
\] (2)

where \(r_{ij}\) is the normalized value of the \(j\)th criterion and \(x_{ij}\) is the value of the \(j\)th criterion reached by the \(i\)th alternative.

(c) Assign weights to each parameter:

\[
v_{ij} = w_{ij} \cdot r_{ij},
\] (3)

where \(v_{ij}\) is the weight of the normalized value and \(w_{ij}\) is the weight of the parameter.

(d) Find and label PIS and NIS alternatives. These fictitious limits comprise real values, in most cases, and hypothetical alternatives:
\[ H_j = \max(w_{ij}), \quad D_j = \min(w_{ij}), \quad (4) \]

where \( H_j \) is PIS, and \( D_j \) is NIS.

(e) Compute the distance from these alternatives:

\[
d^+_i = \left[ \sum_{j=1}^{k} (w_{ij} - H_j)^2 \right]^{1/2}, \quad d^-_i = \left[ \sum_{j=1}^{k} (w_{ij} - D_j)^2 \right]^{1/2}, \quad (5)\]

where \( d^+ \) is the distance from the PIS alternative and \( d^- \) is the distance from the NIS alternative.

(f) Calculate the relative distance from the PIS alternative (in terms of alternatives, minimizing the distance from the PIS (\( d^+ \)) and maximizing the distance from the NIS (\( d^- \)) are desired):

\[
c_i = \frac{d^-_i}{d^+_i + d^-_i}, \quad (6)\]

where \( c_i \) is the relative distance from the PIS alternative.

Within each of the MCDM methods, an equally important part of the procedure is to find out how important each of the selected indicators is. Keršuliene et al. [83] divided approaches to weighting into four groups: subjective, expert, objective, and integrated (which are a mix of previous approaches). In the present study, we worked with a group of objective methods that determine the weights of indicators based on a predetermined mathematical model unique to each method, without the decision maker having an influence on this result. Among the objective methods we can include, e.g., CRITIC (CRiteria Importance Through Intercriteria Correlation), MW (Mean Weight), SD (Standard Deviation), and SVP (Statistical Variance Procedure). For processing purposes, the CV method was used and calculated according to Singla et al. [84]. This method was described in more detail by Yalcin and Unlu [85] and was also used in research by Vavrek and Chovancová [73].

The results of the CV–TOPSIS technique were then used in a multiple regression model with an additive type of linkages between independent variables:

\[ GCI = a \cdot \text{Patent} + b \cdot \text{R&D} + c \cdot \text{TeDe}, \quad (7) \]

where Patent is the number of patents per million population; R&D is the research and development expenditure as a percent of gross domestic product; and TeDe is the tertiary education as a percent of population.

The explanatory power was evaluated by the coefficient of determination:

\[ R^2 = \frac{\sum_{i=1}^{n} (y_i - \hat{y}_i)^2}{\sum_{i=1}^{n} (y_i - \bar{y})^2}, \quad (8) \]

where \( y_i \) is the measured value of the dependent variable; \( \hat{y}_i \) is the estimated value of the dependent variable; \( \bar{y} \) is the average value of the variable.

The results obtained in this way were complemented by another apparatus of mathematical–statistical methods (depending on the nature of the data), with which we can include, in addition to the moment characteristics:

- The Shapiro–Wilk test:

\[ SW = \frac{(\sum u_i x_i)^2}{\sum u_i^2 (x_i - \bar{x})^2}, \quad (9) \]

where \( u_i \) is the constant; \( x_i \) is the value of the \( i \)th statistical unit; and \( \bar{x} \) is the average value of the variable.

- The Kruskal–Wallis test:
where \( n \) is the number of observations or file size; \( n_i \) is the number of observations in the \( i \)th group; and \( T^2_i \) is the total number of ranks in the \( i \)th group.

- Levene’s test:

\[
W = \frac{(N - k) \sum_{i=1}^{k} N_i (Z_i - Z_{..})^2}{(k - 1) \sum_{i=1}^{k} \sum_{j=1}^{N_i} (Z_{ij} - Z_i)^2}
\]

All analysis and data processing were performed in MS Excel, Statistica 13.4, and Statgraphics XVIII.

4. Results

4.1. The Efficiency of EU Countries Measured in the Context of the Knowledge Economy and Competitiveness Indicators

The tertiary education was evaluated as a percentage of the country’s population. We chose this form for the sake of improved comparability of the results obtained, which minimized the differences caused by the different size of individual countries. In this comparison, the results in the EU countries were achieved without any significant differences. Over the period under review, the results ranged from 3.72\% to 4.03\% on average in the EU. There were also values outside this interval during the 11 monitored years. The lowest population with tertiary education measured as a percent of the inhabitants was in 2008 in Malta (2.33\%), while the highest in Greece (6.83\%) in 2017. Overall, the countries with the most stable development of this indicator were the United Kingdom and Bulgaria. On the contrary, the greatest variance of the achieved values was recorded in Romania, Cyprus, and Lithuania. In 2017, Greece, Denmark, and Finland represented the countries with the best performance in this indicator.

The R&D area as an indicator of the knowledge-based economy was evaluated by expressing the volume of the research and development expenditure as a percentage of gross domestic product. The countries with the lowest average of this indicator were Cyprus (0.46\%) and Romania (0.47\%). Within these countries, the lowest value was achieved throughout the reference period. In contrast, the best performances of this indicator were in Finland (3.73\%) and Sweden (3.49\%). The United Kingdom represented in the analyzed period the country with the most stable development.

We evaluated the number of patents as a value per million inhabitants. This was for improved comparability of countries’ performances. However, this indicator showed significant differences between countries. The best-performing countries were worth around 300 patents per million inhabitants (Finland and Sweden). At the same time, the weakest countries as Bulgaria, Greece, Romania, and Croatia achieved values ranging from 0.5 to 10 patents per million inhabitants.

The competitiveness of the country was evaluated in relation to the area in question using the GCI. In this index, the 12th pillar is focused on assessing the competitiveness of an area called Innovation. The countries could reach a score of 1–7 in the period 2008–2017. The worst results (2.9) in our sample of countries were achieved by Bulgaria (2009), Slovakia and Romania (both in 2011), and Croatia (2017). The best results were obtained in Sweden in 2011 (5.76) and in Finland in 2013 (5.79). The countries with the most stable development in this pillar included Poland and Denmark.
4.2. Evaluation of Hypothesis Testing

First, we focused our attention on the testing of Hypothesis 1. In a comprehensive assessment, EU countries (with the exception of Luxembourg) were evaluated for the period 2008–2017. The structure of these results is shown in Figure 3.

The overall results can be considered stable, which confirmed the variation range of individual annual results in the range of 0.577–0.682 of relative distance to the PIS alternative as well as their confirmed homoskedasticity (LE = 0.066; \( p = 0.99 \)). From the distribution point of view, we observed a slightly positive skewness, i.e., a higher incidence of below-average countries, which is also illustrated in Figure 3. This characteristic persisted across the whole reporting period and did not change the mean value of the results (\( Q = 2.100; \ p = 0.98 \)).

From the point of view of individual countries, shown in Figure 4, it was possible to observe significant differences, which, due to variability of results, can be described as long term, as opposed to persisting in the period under review. The differences between countries were thus confirmed in the mean value of their results (\( Q = 238.555; \ p < 0.01 \)) as well as in the variance (\( LE = 2.976; \ p < 0.01 \)). The countries with the most stable results are Denmark (\( v_{DK} = 3.16% \)), Estonia (\( v_{EE} = 3.34% \)), and Portugal (\( v_{PT} = 3.56% \)). On the contrary, the countries with the highest variability of results include Slovakia (\( v_{SK} = 39.19% \)) and Lithuania (\( v_{LT} = 29.54% \)).
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However, the results of individual countries can not only be seen in terms of absolute results, but also in the context of the results of other countries. One option is, for example, to assess countries by placement in each year, as shown in Figure 5. Of course, the differences between the countries in the mean values or variation remained unchanged, but we can observe changes in the variability of such results. Latvia was the only country out of 27 to rank in the same place each year (12th). For countries with stable placement, we can include, e.g., the Netherlands ($v_{NL} = 4.21\%$) or Cyprus ($v_{CY} = 4.27\%)$. An interesting fact is that Denmark as one of the countries with the lowest variability of the absolute results showed a higher variability of placements in different years ($v_{DK} = 14.55\%$).

Considering both views of the overall results shown in Table 1, Sweden (SE) can be described as the best-ranked country, with a narrow lead over Finland (FI) and Germany (DE). The worst-ranked countries (shown in Figure 6) include Romania (RO) and Cyprus (CY).
Table 1. Mean value (median) of absolute results and placements in individual years 2008–2017.

| Country   | MED cz | MED Rank | Country   | MED cz | MED Rank |
|-----------|--------|----------|-----------|--------|----------|
| SE Sweden | 0.684071 | 1        | ES Spain  | 0.204981 | 15       |
| FI Finland| 0.660245 | 2        | PT Portugal| 0.177833 | 16.5     |
| DE Germany| 0.670887 | 3        | HU Hungary| 0.174564 | 17       |
| DK Denmark| 0.627575 | 4        | EL Greece | 0.163008 | 18       |
| AT Austria| 0.603422 | 5        | LT Lithuania| 0.155194 | 18.5     |
| NL Netherlands| 0.628195 | 6        | PL Poland | 0.150543 | 20       |
| BE Belgium | 0.471093 | 7        | LV Latvia | 0.131205 | 21       |
| FR France | 0.464415 | 8        | HR Croatia| 0.116751 | 22.5     |
| UK United Kingdom | 0.332186 | 9        | SK Slovakia| 0.112336 | 22.5     |
| SI Slovenia | 0.303795 | 10       | BG Bulgaria| 0.096345 | 25       |
| IE Ireland | 0.30315 | 11       | MT Malta | 0.095575 | 25       |
| IT Italy | 0.278197 | 12       | CY Cyprus | 0.087886 | 26       |
| CZ Czechia | 0.210837 | 13.5     | RO Romania | 0.072488 | 26.5     |
| EE Estonia | 0.213831 | 14        |           |        |          |

Figure 6. Ranking of countries based on the results CV–TOPSIS method in terms of median.

4.3. Identification of Causes of Results Using Regression Analysis

In the above section, we look at the overall results of the multi-criteria assessment, which was assessed by countries simultaneously on the basis of three indicators—Patents, R&D, and TeDE. To evaluate the hypotheses, we tried to set the influence of these indicators on the score of the 12th GCI pillar using multiple regression, which was as follows in Table 2.

Each of the calculated regression models showed a high predicative ability (R² > 98.5%), and we could divide individual countries into four groups based on the results. The first group includes the countries where each of the three indicators positively influenced the score of the 12th GCI pillar. These countries include Sweden (SE), Croatia (CR), and Estonia (EE). The second group consisted of countries such as the United Kingdom (UK) and Bulgaria (BG), for which we may consider the impact of the Patents indicator as negative. The third group of countries is represented by Finland (FI) and Czech Republic (CZ), where the negative impact of the R&D indicator was recorded. The fourth group is represented by countries with a negative influence from the TeDe indicator, e.g., Italy (IT) and Cyprus (CY).
Table 2. Impact of dependent variables within the applied regression model at the country level.

| Country | Patents | R&D | TeDe | Country | Patents | R&D | TeDe |
|---------|---------|-----|------|---------|---------|-----|------|
| BE Belgium | + | + | + | LT Lithuania | - | + | + |
| BG Bulgaria | - | + | + | HU Hungary | + | + | + |
| CZ Czechia | + | - | + | MT Malta | + | - | + |
| DK Denmark | + | + | - | NL Netherlands | + | + | + |
| DE Germany | + | + | - | AT Austria | + | - | + |
| EE Estonia | + | + | + | PL Poland | + | + | + |
| IE Ireland | - | + | + | PT Portugal | + | - | + |
| EL Greece | + | + | + | RO Romania | + | - | + |
| ES Spain | + | + | + | SI Slovenia | + | + | - |
| FR France | + | + | + | SK Slovakia | + | + | + |
| HR Croatia | + | + | + | FI Finland | + | - | + |
| IT Italy | + | + | - | SE Sweden | + | + | + |
| CY Cyprus | + | + | - | UK United Kingdom | - | + | + |
| LV Latvia | + | + | + |

Table 3 gives a comprehensive view of individual groups that were classified based on the results by the impact of selected indicators on the score of the 12th pillar of the GCI.

Table 3. Division of countries into groups according to the impact of indicators on competitiveness.

| 1st Group | 2nd Group | 3rd Group | 4th Group |
|-----------|-----------|-----------|-----------|
| Estonia   | Bulgaria  | Belgium   | Denmark   |
| Spain     | Lithuania | Czechia   | Germany   |
| France    | UK        | Greece    | Italy     |
| Croatia   |           | Malta     | Cyprus    |
| Latvia    |           | Portugal  | Austria   |
| Hungary   |           | Romania   | Slovenia  |
| Netherlands|          | Finland   |           |
| Poland    |           |           |           |
| Slovakia  |           |           |           |
| Sweden    |           |           |           |

As shown in Figure 7, it is not possible to determine the impact of the monitored indicators on individual groups of countries, so it is not possible to predict, with the increase or decrease of a single indicator, the score of the 12th pillar of the GCI of a country.

![Figure 7](image-url)  
**Figure 7.** Influence of indicators on the score of the 12th pillar of the GCI in the context of overall placement.
5. Discussion

Nowadays, there is a constant dialogue about the knowledge economy and its importance, both in the field of business environment and in the academic sphere [22]. Krstić and Stanišić [68] argued that a knowledge-based economy is more efficient, which is mainly due to the use of knowledge as a basic source of development. The results of their research confirm the need for the implementation and realization of innovation policies, greater investment in education and training, the development of technological capabilities, and information infrastructure. The authors’ analysis confirmed the importance of stimulating economic environments in an effort to use knowledge and expertise effectively in the field of production, services, and exports of EU countries. Jednak and Kragulj [3] confirmed that the EU has achieved quite positive results in R&D investments, which represented 2.02% of the GDP in 2013. Positive results have been achieved in education, too. These authors argued that a knowledge economy focusing on education supports the growth in productivity, innovation potential, and the country’s competitiveness. Support for research and development contributes to the creation of innovation, which, in line with the efficient use of natural resources, leads to an increase in the competitiveness of a country on a global scale. Dima et al. [6] divided the assessment approach of the country’s competitiveness into two perspectives. The first was an evaluation based on soft dimensions, including R&D expenditure as a percentage of GDP, lifelong learning, and tertiary education. On the other hand, the hard dimensions include the level of GDP, the energy intensity, and the debt-to-equity ratio. Their empirical analysis confirmed that innovation and education are among the most important factors in competitiveness. According to them, it is well known that innovations lead to smart economic growth, and knowledge creation increases a country’s chances of economic success in today’s competitive and globalized world economy.

Moreover, in their research, Fagerberg et al. [86] identified the variables that are important for economic growth and economic competitiveness. Their results show that, when it comes to competitiveness, there is a clear gap between developed countries with healthy economic growth and the rest of the world. The basic determinant of this development is an optimally set policy in developed countries, which systematically places great emphasis on improving technologies and supporting the knowledge economy.

According to Melnikas [18], the issue of sustainable development, as well as the issue of the transition to a knowledge-based society and economy, is very interdisciplinary. Scientists must reach a consensus on approaches to social and economic development, technological progress, and environmental protection. The regional perspective is an important aspect of research on this issue, as regions differ in terms of different social, economic, technological, and ecological conditions. Thelen [87] argued that differences in the organization of business and work, as well as differences in the approach of institutions that structure mutual relations with each other and with the state, have led these countries along different paths in terms of their level of implementation of the knowledge economy. However, Brodowka-Szewczuk [53] argued that adequate state policy relevantly determines the progress of innovativeness in companies. In this way, it also minimizes the risk of destabilization and deterioration in the economic situation and stimulates high-tech changes in the economy. The internal factors existing within a company define the company’s innovative needs and means that can be used for innovations, the human resources in innovative processes, and the importance of innovation for the further development of the company. The basic variable that is a part of expenditure indices is the amount of expenditure on R&D, presented as a percentage of gross domestic product.

6. Conclusions

As shown above, the knowledge-based economy is a very important part of the world today and in many respects affords countries a competitive advantage, which can more or less be reflected in the country’s competitiveness. Based on the above analyses, test results, and other conclusions, we can evaluate the established hypotheses and the aim of this study.
From the point of view of individual countries, it was possible to observe significant differences, which, due to variability of results, can be described as long term as opposed to persisting in the period under review. The differences between countries were thus confirmed in the mean value of their results ($Q = 238.555; p < 0.01$) as well as in the variance ($LE = 2.976; p < 0.01$). The analysis confirmed statistically significant differences in the evaluation of the competitiveness of EU countries and this statement confirmed Hypothesis 1.

In Hypothesis 2, we assumed a positive dependence of competitiveness (12th GCI pillar) on the knowledge economy of individual EU countries. This hypothesis was built in three variants. Based on the results presented in Table 2, we can see that, in some countries (placed in Group 1), positive dependencies are achieved in all three indicators. In other countries (Groups 2–4), only some of the indicators showed positive dependencies. Overall, Hypothesis 2 (based on variants H2A, H2B, and H2C) was not confirmed for all EU countries. The dependence of competitiveness on the knowledge economy was not positive.

In Hypothesis 3, we assumed statistically significant differences in terms of competitiveness on the knowledge economy between individual EU countries. As show in Figure 7, it is not possible to assign the impact of the monitored indicators to individual groups of countries, thus it is not possible to predict, with the increase or decrease of a single indicator, the score of the 12th pillar of the GCI of the country. Since the findings presented in Table 3 show differences in the nature of dependencies across countries, Hypothesis 3 was confirmed.

The main aim of this study was to identify the EU country with the strongest competitive position. Based on the results obtained, considering the broader context and the results of CV–TOPSIS as well as the data in Table 1, it was Sweden. This country, as the only one mentioned here, also took into account the sustainability factor discussed below. Sweden was followed by Finland and Germany. We also wanted to determine the impact that selected indicators of the knowledge economy have on the country’s competitiveness in their interaction. We investigated this fact based on the results arising from the testing of Hypotheses 2 and 3. In the case of Sweden, a positive dependence was noted for all examined indicators.

The Europe 2020 strategy emphasizes the economic sustainability of the overall development of the EU community. Among other objectives, the strategy aims to achieve R&D spending of 3% of GDP by 2020. This is a target value for all member countries. Because sustainability is a long-term issue, countries must pay attention to factors that provide them with long-term growth. The research and development issue seems to be significant for a country to achieve competitiveness and sustainability. Focusing on prosperous knowledge economies could be the right path to give whole societies a sustainable standard of living and a more meaningful life. During our selected period of time, we can assess how each EU country has contributed to this goal. If a country managed to increase this value every year to a desired level by various measures, we can discuss building a long-standing competitive position of the country, building sustainability in the economy. Increased R&D spending improves the level of the knowledge-based economy, thereby building the country’s sustainability in a competitive environment in the long run.

In this case, sustainability was assessed by comparing EU countries’ achievements with the set Europe 2020 target of 3% of GDP. In 2017, only four countries (Denmark, Germany, Austria, and Sweden) achieved or exceeded R&D spending of 3% of GDP. Only in the case of Sweden was the value of this indicator higher than 3% over the entire monitored period. In Austria, the target value has been reached and exceeded since 2014. In the case of Denmark, in 2009, the value of this indicator was above 3%; subsequently its level fell and again exceeded 3% in 2015. In Germany, the value was higher than 3% only in 2017. It is worth mentioning Finland, where from 2007 to 2014 the values of this indicator were higher than 3%, but decreased slightly in 2015 and fell to 2.73% in 2017.
Based on this comparison, we can claim that sustainability was only identified in countries that have long sought to achieve the required indicator values. These countries were Denmark, Germany, Austria, and Sweden. We would also include Belgium, which has not yet reached the required value of 3%, but the values of this indicator are increasing annually and at the same time they are closest to the required threshold in comparison to other EU countries.

The study has some limitations. From the viewpoint of the future orientation of scientific tasks, it is essential to focus on other knowledge economy indicators that may affect the competitiveness and the sustainability of the country. Research should consider such indicators not only with respect to the knowledge economy but also their impact on competitiveness. It would be interesting to determine the indicators that affect or do not affect competitiveness. It might be useful to begin new research on the indicators considered here on a wider group of countries. By expanding the research with new countries and enlarging the sample size, new conclusions and interactions between the research areas may emerge. Another suggestion for future studies is to replace the GCI in the quantification of competitiveness. Instead of using the GCI, another approach or an index that represents the competitive position of the country in numerical terms could be used.

The scientific community can apply this conceptual view to understand how the sustainability and competitiveness of countries integrate with each other and are supported by the transition to a knowledge-based economy. The methods used in the analytical part of this study could be used to assess a sample of countries from other regions. The study also provides useful references for policy makers to understand the importance of transition to a knowledge-based economy in order to ensure the country’s sustainable competitiveness.

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