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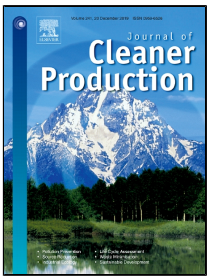

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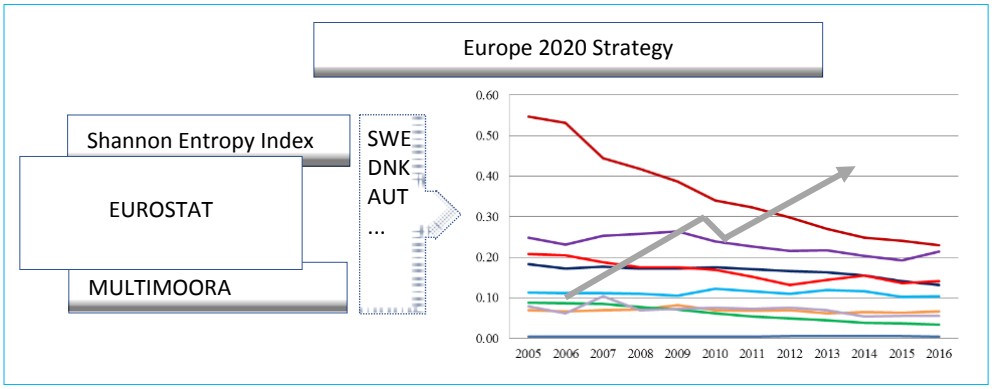
Graphical abstract



Assessment of Progress towards "Europe 2020" strategy targets by Using the MULTIMOORA Method and the Shannon Entropy Index

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Abstract. Through the implementation of the "Europe 2020" strategy, the European Union (EU) strives to ensure sustainable growth and development by 2020, improve its competitive position in the global market and become one of the most dynamic knowledge-based economies worldwide. Having in mind the fact that the year 2020 is approaching, some important questions arising and need to be addressed. Which Member States are the best and which are the worst performers in the implementation of the "Europe 2020" strategy? How can they be classified according to the progress they have made in the strategy implementation? In which strategic priorities is the gap amongst Member States high and in which is the state relatively uniform?
In order to address these questions, a multi-objective decision-making approach is used for the ranking and classification of the EU countries according to the progress achieved in the implementation of the strategy. The weights of the considered criteria are calculated objectively by applying the entropy method. The entropy method is also used for the calculation of the Shannon Entropy Index, which measures the inequality in the performances of the Member States in each strategic priority. The obtained

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results pointed out the Sweden, Denmark and Austria are the best performers in strategy implementation. Among EU-15, Finland and France were also positioned relatively high in the rankings. On the other hand, some new Member States achieved significant progress in the strategy implementation and over performed some old Member States, like Lithuania, Slovenia, Croatia and Czech Republic, so they joined group of Core countries. In contrast to them, Belgium, Bulgaria, Spain, Italy, Cyprus, Luxembourg, Malta, the Netherlands, and Romania have an unfavorable position in the final ranking, for which reason they are classified into the group of the Peripheral countries. So, these countries should make considerable effort in the future to achieve their national targets in most of strategy priorities and contribute to full implementation of the strategy at the EU level.

Regarding the progress in strategic priorities, the values of the Shannon Entropy Index indicated that relatively higher differences among the EU countries still exist in the development of renewable energy production and investments in research and development (R&D). These priorities are very important for achieving smart and sustainable growth and reducing the gap among Member States in mentioned priorities require, before all, higher investments. So, some additional funds should be allocated for these purposes to countries which significantly lagging behind in reaching their national targets in these priorities.

Keywords: Europe 2020, sustainable development, MULTIMOORA, Shannon Entropy Index

1. Introduction

In the era of globalization, the 4.0 industry, frequent economic crises, the migrant crisis, global warming, and ecological hazards, sustainable development has become the greatest challenge for policymakers worldwide (Stec and Grzebyk, 2018). Namely, the development of advanced technologies and the intensified globalization process have not only resulted in the improved living conditions of citizens and greater wellbeing, but also in increased gaps in economic and social development between the EU and its major competitors on the global market. Intensified competitive pressures have forced policymakers in the EU to restructure the economies of its Member States, boost the transnational innovation capacity and decrease the innovation gap amongst the countries (Héraud, 2011). The development of Industry 4.0 and the changes it brings (which are reflected in the disruption of traditional approaches to manufacturing, the evolving of networked manufacturing systems, the decentralization of production

control and decision-making, etc.) have led to the emergence of the need for coordinated actions and greater cooperation among industries and countries (Santos et al., 2017).

Other great challenges the EU was faced with were the emergence of the global economic crisis in 2008 and the accession of the three relatively underdeveloped economies (namely Bulgaria, Romania, and Croatia), which further deepened the existing structural imbalances. The EU enlargement in 2004 had already increased the level of territorial inequality, and the next two enlargements made it even more pronounced, threatening to jeopardize the EU internal cohesion (Evers, 2010). The inequality gap was further widened by the occurrence of the migrant crisis since the migrant inflow and migrant poverty vary a lot across the EU countries. The socioeconomic integration of immigrants and their access to the labor market were not adequately facilitated, which resulted in major poverty gaps amongst the EU countries (Hooijer and Picot, 2015).

Some of these challenges are incorporated into the "Europe 2020" Strategy, whereas some have arisen in the course of its implementation and have seriously been hampering and slacking the achievement of the defined targets. The mentioned challenges which had emerged before 2010 hampered the implementation of the Lisbon Strategy, so the necessity for the formulation of a new strategy has arisen. The "Europe 2020" was launched in 2010 to support the implementation of the other measures for overcoming the crisis (Colak and Ege, 2013). Since then, the "Europe 2020" Steering Committee has been coordinating the network of the National Economic and Social Councils (ESCs) and the other organizations involved to maintain the planned pace of the strategy implementation. To ensure the achievement of the defined goals at the EU level, the national targets have been defined, and they are formulated according to the economic development of each Member State. In that sense, there is a great diversity between the Old Member States and New Member States in terms of the prescribed targets and the progress made in the strategy implementation (Balcerzak, 2015).

Eight years after the strategy adoption, the EU is being faced with a dangerous and critical standstill in its implementation. If the policymakers cannot manage to steer the strategy in a new direction, they run a serious risk of failing to achieve the defined targets, as it was the case with the Lisbon Strategy (Bongardt et al., 2010). To achieve this goal, it is very important to evaluate the progress of individual countries and developments in reaching targets for each strategic priority at the EU level. A large number of authors have recognized the importance of such an analysis.

Taking into consideration the data and methods employed by other authors, as well as their obtained results and the conclusions, it is possible to present the current state-of-the-art in this research topic. The majority of studies are focused on some strategic priorities and/or one or a group of the EU countries. For example, Moreno and García-Alvarez (2018) focused their research on resource efficiency in the EU countries; Arriazu and Solari (2015) researched the importance of education for the implementation of the strategy; Marx et al. (2012) investigated only the employment and poverty dimensions of the strategy; Káposzta and Nagy (2015) analyzed the implementation of all strategic priorities in the Visegrad countries; and Bogliacino (2014) analyzed the effects of inequality on sustainable and inclusive growth. So, there are very few papers aimed at evaluating the implementation of the Europe 2020 goals in all EU countries, taking into consideration all the strategic priorities. However, numerous of them analyzed the period before the strategy adoption. There are no studies dealing with the analysis of developments in each strategic priority individually and the comparison of the progress made in each one of them. There is a lack of studies that will answer the most important questions, namely:

- Taking all strategic priorities into account, which the EU Member States are the best and which are the worst performers in the implementation of the "Europe 2020" strategy?
- How can the EU Member States be classified according to the progress they have made in the strategy implementation?
- In which strategic fields (priorities) is the gap amongst the EU Member States high and in which is the state relatively uniform, i.e. where are the differences between the countries almost insignificant?

The results of this study should fill these research gaps. So, it can be concluded that its research novelty reflects in:

- the fact that it deals with the parallel analysis of the progress made both in terms of the country and in terms of the strategic priority, and
- the introduction of the Shannon Entropy Index in the investigation of this issue.

In this study, the progress made in achieving the "Europe 2020" goals have evaluated using the MULTIMOORA method and the Shannon Entropy Index. The MULTIMOORA method was used to conduct a comparative analysis of the EU countries by taking into consideration the nine headline indicators and to group them according to the level of the progress the countries have made in achieving the defined targets. The Shannon Entropy

Index was used to assess the differences amongst the EU countries concerning the implementation of the individual strategic priorities.

Based on the obtained results, policymakers can define some measures that could help the strategy to fulfill its purpose in the future. Bearing in mind the fact that the implementation of the proposed measures will imply a large number of investments, the obtained results can also be the starting point for the formulation of an appropriate investment plan.

In order to assess the performance of the Member States with respect to their fulfillment of the objectives defined by the "Europe 2020" Strategy, the rest of the paper is organized as follows: Section 2 gives an overview of the current, relevant literature on this issue; in Section 3 the data used and the methodology applied – the MULTIMOORA method and the entropy method – are presented; in Section 4, the obtained results and discussion on these results are presented. The conclusion is given in Section 5.

2. Literature Review

There are a variety of papers aimed at assessing the progress made in the implementation of "Europe 2020" in terms of the considered strategic priorities and the countries, and the methodology applied. As it was mentioned in introduction, the majority of the authors have focused their research studies on a particular strategic priority and/or a country. However, there are far fewer papers aimed at investigating how far away each of the Member States is from the targeted levels for all strategic priorities considered together.

One such paper is a study carried out by Balcerzak (2015). This author assessed the performance of the Member States in the strategy implementation by the application of the zero unitarization method. The results obtained in this study pointed out that there was a significant diversity between the New and the Old Member States in the progress made in the implementation of the strategy in the period 2004-2013. However, the New Member States have made significant progress in the "Europe 2020" strategy implementation and have managed to catch up with the EU-15. Particularly favorable results were achieved in terms of the climate/energy targets, as well as the education and the quality of human capital, whereas the least progress was made in the sphere of investments in research and development. On the other hand, some of the most advanced EU economies, such as Germany, France, and Italy, recorded rather moderate progress in the strategy implementation.

Stec and Grzebyk (2018) employed the same methodology but for the period 2009-2014. The obtained results pointed out that Sweden, Finland,

Denmark, and Austria were the best performers in 2014, whereas Romania, Bulgaria, Italy, Malta, Spain, and Greece were being faced with problems in the implementation of the strategy. Their results also pointed out that some of the EU-15 countries had failed to incorporate the "Europe 2020" goals in their long-term development programs, whereas amongst the New EU members there are the countries that set the strategic goals as their top priorities in their development strategies. As a result, some of the Old Member States did not succeed in achieving the defined targets, whereas some New Member States have made significant progress in meeting the strategy goals. Also, there are the authors who used a similar approach based on the development of appropriate synthetic indices for the assessment of the progress made in achieving the defined targets – Hudrliková (2013) developed the Composite Indicator (CI), Colak and Ege (2013) calculated the composite indices for the overall strategy and each growth priority, and Pasimeni (2013) constructed the Europe 2020 index. However, those studies employed the data set for the period preceding the launching of the strategy.

Fura et al. (2017) assessed the progress made by the Member States in the "Europe 2020" strategy implementation in the years 2004, 2010 and 2014 by applying the linear ordering method and a synthetic measure with the median. Firstly, they took into account all of the headline indicators of the strategy, after which they reduced the number of the indicators by applying the coefficient of variation (a relative standard deviation) and the Pearson correlation coefficient. They performed the ranking and classification of the EU countries for the chosen years by applying the synthetic measure with the median. The results highlighted the fact that the leaders in meeting the strategic targets amongst the EU-15 were Austria, Denmark, Sweden, and Finland, whereas the best performers amongst the New Member States were Slovenia and the Czech Republic. The authors concluded that there was significant room for progress in both groups of the countries. There are, however, three South European countries – Romania, Greece, and Bulgaria – which have rather low possibilities to implement the necessary measures in the near future.

Taking into account the mentioned studies, one can conclude that the majority of the authors strived to assess performances in the strategy implementation by synthesizing all of the strategic priorities into a single indicator as a measure of progress in all the considered fields. Multi-Criteria Decision-Making (MCDM) methods can also be a very useful tool for this purpose and the Multi-Objective Optimization by a Ratio Analysis (MOORA) method proposed by Brauers and Zavadskas (2006) has been one

of the most popular in the last decade. Based on this method, they further developed the MULTIMOORA (MOORA plus the full multiplicative form) method (Brauers and Zavadskas, 2010), which has been successfully used to solve a number of different decision-making problems in different fields: the supplier selection (Maghsoodi et al., 2018), the logistic service provider selection (Awasthi and Balezentis, 2017), the material selection (Ilce and Ozkaya 2018), the personnel selection (Balezentis et al., 2012), healthcare waste management (Liu et al. 2014), the CNC machine selection (Kumar Sahu et al., 2014), the robot selection (Datta et al. 2013), construction (Kildiene 2013), a reduction in energy losses in heating (Kracka et al. 2010), finance (Brauers and Zavadskas, 2011).

The MULTIMOORA method is also used to assess the achievement of the priorities of the "Europe 2020" Strategy. However, these papers covered the period prior to the launching of the strategy – Balezentis and Balezentis (2011) applied data for the period 2000–2008, and Brauers and Zavadskas (2013) applied data for the period from 2010 to 2012. In that sense, one of the main contributions of this paper reflects in its assessment of the performances of the EU-28 in achieving all of the headline "Europe 2020" strategy targets according to the Eurostat indicators for the year 2016 (as the latest available data for all indicators). The MULTIMOORA method, accompanied by the results of the Shannon Entropy Index, has enabled a comprehensive insight into the strategy implementation. Namely, the MULTIMOORA method is employed in order to indicate the rankings of countries, whereas the Shannon Entropy Index is applied to identify the strategic priorities where the biggest differences amongst the EU countries have been identified. In that way, it is possible to redirect strategic measures and funds towards the countries and the priorities where there is significant room for progress.

3. Data and Methodology

The main indicators and methods used for the ranking and classification of the EU countries according to the implementation of the "Europe 2020" strategy, and for assessing the level of strategy implementation, too, are considered in this section

3.1. Data

To evaluate the overall progress made by the EU countries in the implementation of the strategy, the data on all the headline indicators labeled as the "Europe 2020 Indicators" was used (Bley et al. 2017). The

European Commission uses these indicators are for monitoring of progress in meeting prescribed goals and this is why these indicators are used in this study. They are grouped into the following fields:

1. **Employment** – This field is represented by the employment rate defined as the number of employed persons aged 20-64, expressed as a share of the total number of persons in this contingent of the population. It is used to measure progress in inclusive growth. This issue became especially important after the global economic crisis, the sovereign debt crisis and the migrant crisis that exerted pressure on the EU labor market. The EU economy could not create enough new jobs to meet the growing demand in the labor market. Apart from the need to increase the employment rate, it is also necessary to provide employment quality through the improvement of workers' health, well-being and work motivation (Van Aerden et al., 2014).
2. **Research and Development –** The indicator used in this field is the share of the gross domestic expenditure on research and development in the GDP. Since the R&D output is often intangible and difficult to quantify (Pešić et al., 2016), this indicator is applied to present inputs in R&D activities. It includes the expenditures of private enterprises and non-profit organizations, the government and higher-education institutions, and illustrates progress in smart growth. The European Commission declared its intention to transform the EU into a knowledge-based and innovation-driven economy, with the final aim of improving competitiveness in the global market. Transition to such a kind of economy requires the generation, exploration, transfer, and application of knowledge. Bearing in mind the fact that worldwide access to information is enabled, knowledge and skills have become the assets that can boost economic development and competitiveness (Priede and Pereira, 2013).
3. **Climate Change and Energy –** In this field, there are three indicators, which taken together measure progress in sustainable growth. They are related to energy consumption and greenhouse gas (GHG) emissions, taking into consideration the fact that the management of energy use and a reduction in the greenhouse gas emissions is important for sustainable growth (Nabavi-Pelesaraei et al., 2016). These indicators are:
   - the share of renewable energy in the gross final energy consumption (in %), or the so-called renewables, which indicates the usage of the energy produced from renewable sources.

- the GHG emissions index, with the base year 1990, (in %) is one of the important measures of sustainable growth, having in mind the fact that the gases in this group, such as CO_2, N_2O, and CH_4, cause global warming and climate changes. In order to make this indicator comparable, this group of gases is converted to CO_2 equivalents. It indicates a change in GHG emissions in the considered year in comparison with the year 1990. It should be mentioned that agricultural production has been identified as a major contributor to GHG emissions at the global level, so the level of emissions from this source can be reduced by using standard agriculture machinery (Nabavi-Pelesaraei et al., 2013).
- primary energy consumption per capita (in million tons of the oil equivalent – Mtoe) indicates aggregate demand for energy in the country. Bearing in mind the fact that this indicator should be comparable, it was used in per-capita terms.
- the final energy consumption per capita (in Mtoe) represents the total consumption of energy by households, the industry, agriculture, and other end users. It was also used in the per-capita form in order to ensure comparable data for analysis.

4. **Education –** This group consists of two indicators of smart growth:
   - *Early leavers from education and training*, given as a share of the population aged 18-24, who only finished secondary school and did not attend any training courses and additional education during the last four years prior to conducting the survey. Early school leaving is a serious economic and social phenomenon, which has a great influence both on individuals and on society. At the individual level, it affects the level of workers' productivity and earnings. On the other hand, it can create significant spillovers, which may affect the economic growth of the country. Moreover, a high level of education reduces the probability that an individual will be engaged in socially costly activities, such as smuggling and organized crime, improves the health of the nation and increases social participation (Brunello and De Paola, 2014).
   - *The tertiary education attainment*, given as a share of the population aged 30-34, who completed tertiary education. Although this share has steadily increased in all EU countries during the past decade, most of them are still characterized by the low level of this indicator in comparison with the U.S. or the EU's other major competitors in the global market. Increased and broadening access to higher education will have positive externalities for economic growth and

the innovation capacity at the EU level in the future (Dragomirescu-Gaina et al., 2015).

5. **Poverty and Social Exclusion –** This field is represented by *people at risk of poverty or social exclusion* (in %), which is considered as one of the very important indicators for inclusive growth. Poverty has become an increasingly pronounced problem in the EU during the last fifteen years. Numerous factors have contributed to a relatively high poverty rate in some countries, such as the accession of the three relatively underdeveloped Balkan countries, the global economic and financial crisis, and the large-scale immigration of refugees and asylum seekers (Michálek and Výbošťok, 2019).

All of the headline indicators were downloaded from the Eurostat database.[†]

3.2. MULTIMOORA Method

Compared to the other MCDM methods, the MULTIMORA method has two specificities:

- it integrates three approaches to the ranking of alternatives, and
- alternatives are ranked according to the Dominance Theory.

3.2.1 Three Parts of the MULTIMOORA Method

The MULTIMOORA method integrates into itself three approaches, namely: The Ratio System (RS) Approach, the Reference Point (RP) Approach, and the Full Multiplicative Form (FMF). According to Brauers and Zavadskas (2010) the computational procedure of the MULTIMOORA method can be described as follows:

Ratio System Approach. In the RS approach, the overall significance of each alternative is calculated as follows:

$$y_i = \sum_{j \in \Omega_{\max}} s_j x_{ij}^* - \sum_{j \in \Omega_{\min}} s_j x_{ij}^* , \tag{1}$$

with:

$$x_{ij}^* = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{n} x_{ij}^2}} , \tag{2}$$

[†] https://ec.europa.eu/eurostat/web/europe-2020-indicators/europe-2020-strategy/main-tables

where: y_i denotes the overall significance of the alternative i, s_j is the significance of the objective j, x_{ij}^* denotes the normalized response of the alternative i to the objective j, x_{ij} is the response of the alternative i to the objective j, $\Omega_{\max}$ and $\Omega_{\min}$ denote the sets of the benefit and cost objectives, respectively, i denotes the alternatives; i=1,…, m, and j denote the objectives; j=1,…, n.

In the RS approach, the alternatives with a higher value of y_i are preferable.

Reference Point Approach. In the RP approach, alternatives are ranked based on their maximum distance to the reference point, where the maximum distance of each alternative to the reference point is calculated as follows:

$$d_i^{\max} = \max_j (s_j \mid x_j^* - x_{ij}^* \mid), \tag{3}$$

with:

$$x^* = \{x_1^*, x_2^*, ..., x_n^*\} = \left\{ (\max_i x_{ij}^* \mid j \in \Omega_{\max}), (\min_i x_{ij}^* \mid j \in \Omega_{\min}) \right\}, \tag{4}$$

where: $d_i^{\max}$ denotes the maximum distance of the alternative i to the reference point.

In the RP approach, the alternatives with the lower values of $d_i^{\max}$ are more preferable.

Full Multiplicative Form. In the FMF approach, the overall utility of each alternative is calculated as follows:

$$u_i = \frac{a_i}{b_i}, \tag{5}$$

with:

$$a_i = \prod_{j \in \Omega_{\max}} s_j x_{ij}^*, \tag{6}$$

$$b_i = \prod_{j \in \Omega_{\min}} s_j x_{ij}^*, \tag{7}$$

where: u_i denotes the overall utility of the alternative i, a_i and b_i denote the utility of the alternative i obtained based on the benefit and cost criteria, respectively.

In this approach, the alternatives with a higher value of u_i are preferable.

3.2.2 The Final Ranking of Alternatives

As a result of applying the foregoing three approaches, three different ranking lists are formed.

The final ranking of the alternatives in the MULTIMOORA is based on ordinal dominance theory, i.e. the alternative with the highest number of appearances in the first positions on all ranking lists is the best-ranked alternative.

For more detailed information about ordinal dominance theory and its application, please see in Brauers and Zavadskas (2014).

3.3 Entropy Method

Entropy can generally be defined as a measure of chaos or the disorder of a system (Downarowicz, 2011). The entropy concept was first used in thermodynamics, after which Shannon introduced it into information theory (Shannon, 1948). The Shannon approach was later adopted by many authors and used in solving various problems from different research fields. In economics, it is used for structural change analysis (Joya, 2015), economic modeling (Sequeira et al., 2018), finance (Zhou et al., 2013), regional analysis (Bouvet, 2010) and alike. Shannon's entropy is also used to determine the significance of criteria in many MCDM problems.

Shannon's entropy identifies the amount of uncertainty about an event associated with an appropriate probability distribution. In this case, those "events" are the "Europe 2020" indicators, and they can be marked as x. The information obtained from the appearance of a certain event is determined by the monotonically decreasing function with the probability p, which can be displayed in the form ln $(1 / p)$ = - ln (p). For a series of events x_{i1} and with the probabilities p_i, it follows that:

$$0 \leq p(x_i) \leq, \sum_{i=1}^{m} p(x_i) = 1, \tag{8}$$

where ln denotes the natural logarithm, x_i represents an appropriate "Europe 2020" indicator for the country i; $i = 1, 2 \ldots m$.

The measure of the entropy $H(x)$ is the expected value of this series, which can be presented in the following manner:

$$H(x) = -\sum_{i=1}^{m} p(x_i) \ln(x_i) . \quad (9)$$

3.3.1 Determining the Significance of Criteria by Using Shannon's Entropy

The entropy method is used to determine the objective significance of criteria in many articles, such as Gou et al. (2017), Shemshadi et al. (2011), Wang and Lee (2009), Chan et al. (1999), and so on.

Based on the entropy method, the significance of the objective j is calculated as follows (Wang and Lee, 2009):

$$s_j = \frac{1 - e_j}{\sum_{j=1}^{n} (1 - e_j)}, \quad (10)$$

with:

$$e_j = \frac{1}{\ln(m)} H(x) , \text{ and} \quad (11)$$

$$p_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}}, \quad (12)$$

where: s_j denotes the significance of the objective j, x_{ij} and p_{ij} denote the rating of the alternative i on the objective j, p_{ij} denotes the probability of x_{ij}, i denotes the alternatives; i=1,…, m, and j denotes the objectives; j=1,…, n.

3.3.2 Shannon Entropy Index

The entropy concept is usually applied in analysis of regional systems, where the entropy approach is employed to identify the most probable spatial structure of a system capable of adapting to numerous uncertain spatial states. So, a conclusion may be drawn that entropy in the regional analysis is a probability concept, illustrating the outcome of a stochastic process (Nijkamp and Paelinck, 1974).

Entropy statistics $H(x)$ provide the basis for the calculation of the Shannon Entropy Index $I(x)$ as a measure of the differences amongst the EU countries according to a certain indicator x. It is calculated as follows:

$$I(x) = H(x)_{\max} - H(x) = \ln(n) - \sum_{i=1}^{n} p(x_i) \ln \frac{1}{p(x_i)}, \qquad (13)$$

where: $I(x) = 0$ shows the absence of inequality, whereas $I(x) = \ln(n)$ denotes the maximum inequality, $0 \le I(x) \le \ln(n)$.

4. Analysis and Results

The procedure used for the ranking and classification of the EU countries based on the progress made in the implementation of the "Europe 2020" Strategy can be described through the following steps:

Step 1. The identification of the indicators for determining the degree of the implementation of the "Europe 2020" Strategy;

Step 2. The determination of the significance of indicators;

Step 3. Data collection and the formation of an evaluation matrix;

Step 4. The construction of a normalized evaluation matrix;

Step 5. The ranking of the countries according to the RS approach;

Step 6. The ranking of the countries according to the RP approach;

Step 7. The ranking of the countries according to the FMF approach;

Step 8. The determination of the final ranking order of the countries based on dominance theory.

Identification and the data used in this study were adopted from the Eurostat database[‡]. The normalized evaluation matrix was formed by applying Eq. (2). After that, the ranking of the EU countries according to the RS, RP and FMF approaches was performed by applying Eqs (1), (3) and (5), respectively.

After that, the assessment of the implementation of the "Europe 2020" strategy was performed based on the Shannon Entropy Index, applying Eq. (13). A detailed description of the procedure for ranking and the evaluation of progress, as well as the assessment of progress in the implementation of the "Europe 2020" strategy, is shown in Fig. 1 and in Subsections 4.1. and

[‡] https://ec.europa.eu/eurostat

4.2.

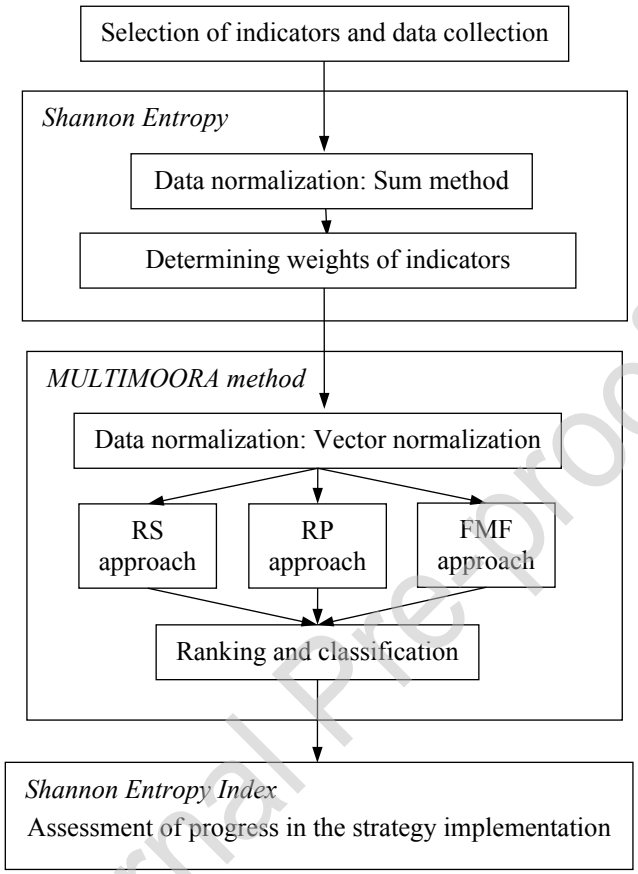

Fig. 1. The procedure used for assessing the progress of the implementation of the "Europe 2020" strategy

4.1. The Ranking and Classification of the EU Countries

The "Europe 2020" Strategy indicators that were used in this study are shown in Table 1. The data set consists of the 9 indicators designated by the symbols ranging from C_1 to C_9.

Table 1. The "Europe 2020" Strategy Indicators

	Indicators	Optimization	Significances (s_j)
C_1	Employment rate	max	0.08
C_2	Gross domestic expenditure on R&D	max	0.16
C_3	Greenhouse gas emissions	min	0.09
C_4	The share of renewable energy in gross final energy consumption	max	0.13

C_5	Primary energy consumption per capita	min	0.11
C_6	Final Energy Consumption per capita	min	0.12
C_7	Early leavers from education and training	min	0.14
C_8	Tertiary education attainment	max	0.09
C_9	People at risk of poverty or social exclusion	min	0.09

As it can be seen from Table1, the appropriate direction of the preference and weights are defined for each indicator to perform the ranking and classification of the EU countries by the MULTIMOORA method. In this approach the Entropy method is used for determining weights of indicators because it provides objective weights. The weights of indicators, shown in Table 1, is determined using Eqs. (10) – (12) on the basis of data shown in Table 2 obtained from Eurostat.

The initial set of data for the year 2016 is presented in Table 2.

Table 2. The evaluation matrix for 2016

Member States	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9
Belgium	67.70	2.49	81.53	8.70	4.32	3.20	8.80	45.60	20.70
Bulgaria	67.70	0.78	57.02	18.80	2.47	1.36	13.80	33.80	40.40
Czech Republic	76.70	1.68	65.62	14.90	3.78	2.35	6.60	32.80	13.30
Denmark	77.40	2.87	73.91	32.20	3.00	2.51	7.20	47.70	16.80
Germany	78.60	2.94	74.05	14.80	3.59	2.63	10.30	33.20	19.70
Estonia	76.60	1.28	48.62	28.80	4.64	2.13	10.90	45.40	24.40
Ireland	71.40	1.18	113.42	9.50	3.07	2.44	6.20	52.50	24.20
Greece	56.20	1.01	89.69	15.20	2.18	1.55	6.20	42.70	35.60
Spain	63.90	1.19	116.43	17.30	2.52	1.77	19.00	40.10	27.90
France	70.00	2.25	85.64	16.00	3.52	2.20	8.80	43.60	18.20
Croatia	61.40	0.85	76.19	28.30	1.94	1.58	2.80	29.30	27.90
Italy	61.60	1.29	83.85	17.40	2.45	1.91	13.80	26.20	30.00
Cyprus	68.70	0.50	152.92	9.30	2.82	2.11	7.60	53.40	27.70
Latvia	73.20	0.44	43.77	37.20	2.19	1.94	10.00	42.80	28.50
Lithuania	75.20	0.85	42.00	25.60	2.09	1.78	4.80	58.70	30.10
Luxembourg	70.70	1.24	87.53	5.40	7.22	6.87	5.50	54.60	19.80
Hungary	71.50	1.21	65.82	14.20	2.44	1.82	12.40	33.00	26.30
Malta	71.10	0.61	99.42	6.00	1.54	1.32	19.20	32.00	20.10
Netherlands	77.10	2.03	91.63	6.00	3.80	2.91	8.00	45.70	16.70
Austria	74.80	3.09	103.06	33.50	3.64	3.22	6.90	40.10	18.00
Poland	69.30	0.97	85.03	11.30	2.48	1.76	5.20	44.60	21.90
Portugal	70.60	1.27	115.77	28.50	2.14	1.56	14.00	34.60	25.10
Romania	66.30	0.48	45.82	25.00	1.59	1.13	18.50	25.60	38.80

Slovenia	70.10	2.00	95.19	21.30	3.24	2.37	4.90	44.20	18.40
Slovakia	69.80	0.79	55.63	12.00	2.85	1.92	7.40	31.50	18.10
Finland	73.40	2.75	84.03	38.70	6.02	4.59	7.90	46.10	16.60
Sweden	81.20	3.25	76.10	53.80	4.75	3.29	7.40	51.00	18.30
United Kingdom	77.50	1.69	63.64	9.30	2.77	2.04	11.20	48.20	22.20

Source: Eurostat.

The final calculation results obtained by applying the three approaches of the MULTIMOORA method, as well as the appropriate ranking orders, are shown in Table 3.

Table 3. The results of the three approaches of the MULTIMOORA method

Member States	RS Approach	RP Approach	FMF Approach	Rank RS	Rank RP	Rank FMF
Belgium	-0.018	0.050	32.187	16	25	21
Bulgaria	-0.037	0.043	31.104	23	16	23
Czech Republic	-0.005	0.043	122.143	11	14	7
Denmark	0.038	0.024	500.589	2	3	1
Germany	0.001	0.043	79.270	8	15	13
Estonia	-0.010	0.035	99.507	12	5	10
Ireland	-0.025	0.049	32.646	20	21	20
Greece	-0.020	0.042	54.524	18	13	16
Spain	-0.049	0.040	18.912	26	9	25
France	-0.001	0.042	102.326	9	10	9
Croatia	0.005	0.042	234.447	6	11	4
Italy	-0.036	0.040	22.083	22	8	24
Cyprus	-0.047	0.049	8.808	25	22	27
Latvia	-0.001	0.049	95.652	10	24	11
Lithuania	0.014	0.042	421.383	4	11	3
Luxembourg	-0.080	0.053	5.414	28	28	28
Hungary	-0.026	0.043	42.103	21	17	18
Malta	-0.056	0.052	10.609	27	26	26
Netherlands	-0.019	0.052	31.387	17	26	22
Austria	0.025	0.022	205.167	3	2	5
Poland	-0.012	0.047	79.407	13	19	12
Portugal	-0.018	0.035	64.483	15	6	15
Romania	-0.040	0.049	34.102	24	20	19
Slovenia	0.009	0.036	197.808	5	7	6
Slovakia	-0.020	0.046	50.679	19	18	17
Finland	0.003	0.029	117.149	7	4	8
Sweden	0.052	0.019	446.161	1	1	2
United Kingdom	-0.013	0.049	65.072	14	22	14

Source: Authors' calculation.

Based on the analysis of the obtained results presented in Table 3, it is possible to conclude that the three considered approaches of the MULTIMOORA method generate different ranking results. In some cases, those differences are not so pronounced; in some cases, however, (such as in the case of Spain, Italy, and Portugal) the results are considerably different. So, the results of the three approaches should be summarized in a single one. The final rank of the alternatives is determined based on dominance theory, as is shown in Table 4.

In addition to the ranking, the EU countries were also classified according to the ranking results in the three groups: Core, Semi-Periphery, and Periphery, as defined by Brauers and Zavadskas (2013). *Core countries* are those that have made significant progress in all or the largest number of the "Europe 2020" strategic fields; *Semi-periphery countries* are those that have made improvements in certain strategic fields, and *Periphery countries* are those lagging behind the previous two groups of countries when the implementation of the strategy is concerned. Bearing in mind the fact that there are 28 countries and three ranking results, the classification of the countries was performed as follows:

1. Core Countries – those with the ranks ranging from 1 to 9,
2. Semi-Periphery – those with the ranks ranging from 10 to 19, and
3. Periphery – those with the ranks ranging from 20 to 28.

The results of the final ranking and classification are accounted for in Table 4.

Table 4. The final ranking and classification of the EU countries

Member States	Rank RS	Rank RP	Rank FMF	Final Rank	Categorization
Belgium	16	25	21	20	Periphery
Bulgaria	23	16	23	24	Periphery
Czech Republic	11	14	7	9	Core
Denmark	2	3	1	2	Core
Germany	8	15	13	11	Semi-Periphery
Estonia	12	5	10	10	Semi-Periphery
Ireland	20	21	20	19	Semi-Periphery
Greece	18	13	16	16	Semi-Periphery
Spain	26	9	25	25	Periphery
France	9	10	9	8	Core
Croatia	6	11	4	6	Core
Italy	22	8	24	22	Periphery
Cyprus	25	22	27	26	Periphery

Latvia	10	24	11	12	Semi-Periphery
Lithuania	4	11	3	4	Core
Luxembourg	28	28	28	28	Periphery
Hungary	21	17	18	18	Semi-Periphery
Malta	27	26	26	27	Periphery
Netherlands	17	26	22	22	Periphery
Austria	3	2	5	3	Core
Poland	13	19	12	13	Semi-Periphery
Portugal	15	6	15	15	Semi-Periphery
Romania	24	20	19	20	Periphery
Slovenia	5	7	6	5	Core
Slovakia	19	18	17	17	Semi-Periphery
Finland	7	4	8	7	Core
Sweden	1	1	2	1	Core
United Kingdom	14	22	14	14	Semi-Periphery

Source: Authors' calculation

According to the data presented in Table 4, it can be concluded that Sweden has the best performances in the strategy implementation. This country was also the best-ranked according to the two MULTIMOORA approaches. Such a favorable position is a result of the significant progress made in almost all fields. This country over-performed the defined targets for employment, climate change, and energy (except for GHG emissions) and education. In addition to Sweden, Denmark (2nd) and Austria (3rd) topped the ranking due to their accomplishment of the national targets in the fields of primary and the final energy consumption, and the tertiary education attainment. In addition to this, Denmark over-performed the national target for the R&D expenditure, for which reason it took a more favorable position in comparison with Austria. Regarding the EU-15, Finland (7th) and France (8th) were also positioned relatively high in the rankings, whereas Germany (11th), the United Kingdom (14th), Portugal (15th), Greece (16th), and Ireland (19th) took lower positions. However, the worst performers amongst the EU-15 were Belgium (20th), the Netherlands (22nd), Italy (22nd), Spain (25th), and, at the very bottom of the ranking list, Luxembourg (28th).

The best-ranked countries in the group of the New Member States are Lithuania (4th) and Slovenia (5th), with the values of the headline indicators exceeding the EU average in various fields. Croatia (6th) and the Czech Republic (9th) also took a relatively favorable position in the final rankings, whereas Estonia (10th), Latvia (12th), Poland (13th), Slovakia (17th), and Hungary (18th) ranked in the lower positions. The worst performers amongst

the New Member States were Bulgaria (24th), Romania (20th), Cyprus (26th) and Malta (27th).

In addition to the rankings, the EU countries were also classified into certain groups according to the progress they had made in the strategy implementation. Sweden, Denmark, Austria, Lithuania, Slovenia, Croatia, Finland, France, and the Czech Republic form the group of the Core Countries. The majority of these countries are the Old Member States that are the drivers of the EU economic development. As can be seen, there are four New Member States in this group. These countries had made a great effort to achieve their national targets, and in some fields, they had better performances than the EU average.

The countries that had made partial progress in the strategy implementation and, accordingly, formed the group of the Semi-Periphery countries are Estonia, Germany, Latvia, Poland, the United Kingdom, Portugal, Greece, Slovakia, Hungary, and Ireland. It consists of five Old Member States, as well as five New ones, and they had generally achieved a relatively higher level of the implementation of the strategic goals than the EU average. It should be noted that the new Member States in this group had managed to catch up with the old ones, having even over-performed some of them in certain fields. Although they had lower performances than the Core Countries, they still have chances to achieve the defined targets in some fields by the year 2020.

Belgium, Romania, Italy, the Netherlands, Bulgaria, Spain, Cyprus, Ireland, Malta, and Luxembourg belong in the group of the Periphery Countries. These countries failed to meet the largest number of national targets and their performances in some fields were far below the national targets and the EU average. Bearing in mind the fact that they had made sluggish progress in the strategy implementation in the year 2016, the possibility for these countries to reach the defined targets by 2020 is extremely small.

4.2. The Implementation of the Strategic Priorities

To assess the differences in the progress made in the implementation of each strategic priority among the EU countries, the values of the calculated Shannon Entropy Index from 2005 (as the year after the largest EU enlargement) to 2016 (as the latest available data) are presented in Fig. 2.

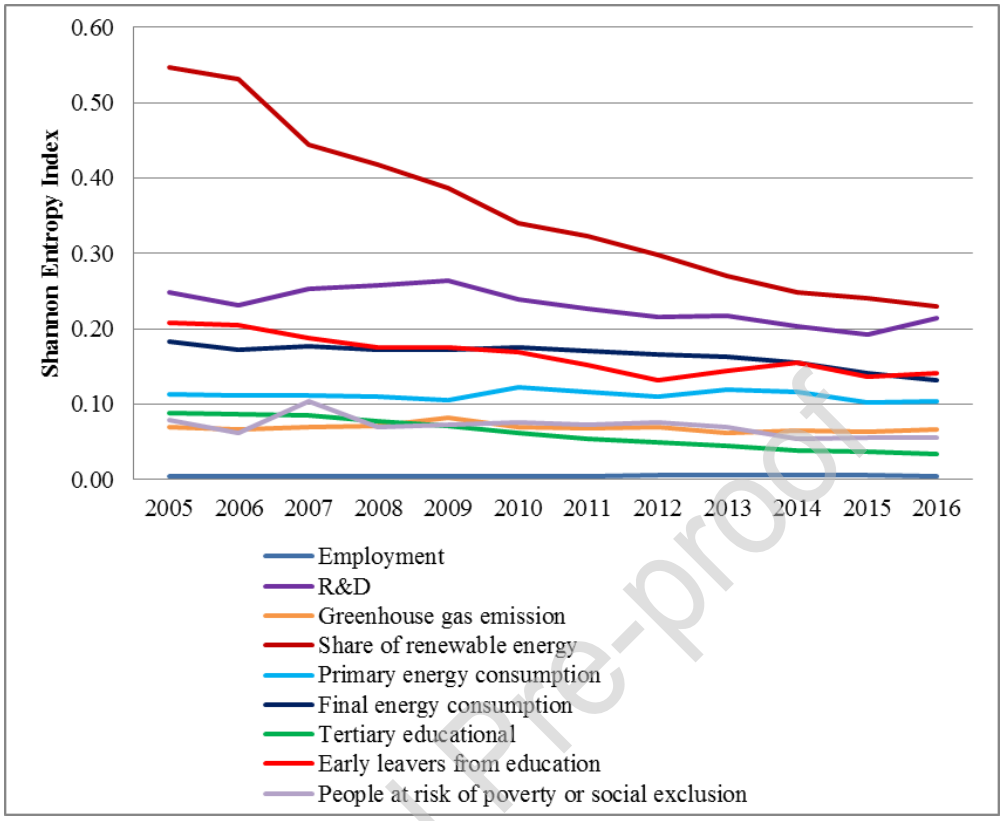

Fig. 2. The Shannon Entropy Index for the "Europe 2020" headline indicators

The calculation of the Shannon Entropy Index enabled the assessment of the differences amongst the EU countries in the progress they had made in the implementation of each strategic priority. The gross domestic expenditure on R&D, early leavers from school, and the tertiary education attainment are the indicators that measure the progress made in the achievement of smart growth. The EU target in the field of R&D expenditures that had been set at the level of 3% of the EU GDP, and, in 2016, the allocation for this purpose amounted to 2.04%. Taking into account the fact that it increased to 2.07% in the year 2017, it seems relatively unachievable to meet this target by 2020. As can be seen in Fig. 2, the differences in this indicator were very high during the period. In 2016, only the gap in the share of renewable energy in the final energy consumption was slightly higher. Such a high Shannon Entropy Index is primarily the result of the considerable differences between the Core Countries that invest 2.2% of the GDP on average and the Periphery

Countries whose average investments only amounted to 1.2% of the GDP. The differences in this field are even more obvious if the fact that this indicator was ranging between 3.3% of the GDP in Sweden and 0.4% of the GDP in Latvia in 2016 is taken into account.

Another important segment of smart growth is the education qualities of citizens in a certain country. The indicators that serve to measure the progress made in this field are "early leavers from education and training" and "the tertiary education attainment". The target in "early leavers from education and training" was set at 10% of the population aged 18-24, and in "the tertiary education attainment", it was set at 40% in the age group of 30-34. Having in mind the fact that the first indicator amounted to 10.6% in 2016, and the second to 39.1%, it seems quite certain that the targets in this field will be met. This data, however, is at the EU level. If one take a look at Fig. 2, it may conclude that the differences amongst the EU countries concerning "early school leavers" are still relatively high although they are certainly lower than in 2005. It is interesting to note the fact that the average of this indicator in the group of the Core Countries amounted to 6.4%, whereas in the group of the Periphery Countries it amounted to 12.7%. The last average rate is close to the EU target, making this goal achievable. It should be emphasized, however, that there are still countries such as Malta (19.2%) and Romania (18.5%) where this rate is far from the national and the EU targets.

When "the tertiary education attainment" is concerned, the situation is quite different. According to this indicator, the differences amongst the EU countries are much smaller in comparison to the previous indicators of smart growth, having slightly decreased during the period (Fig. 2). Such a trend resulted from the fact that 13 EU countries had over-performed their national targets, whereas 7 countries were very close to the target. However, the difference in the average of this indicator between the Core and the Periphery countries is still relatively big in this case – 43.7% and 39.7%, respectively. Another disturbing fact is that there are still countries, such as Romania (25.6%), where this indicator is far below the EU and the national targets.

The second strategic priority of the "Europe 2020" strategy is sustainable growth, represented by the four indicators; the first is GHG emissions, where the differences amongst the EU countries did not change during the period, but they were relatively low in comparison to previously mentioned indicators. The EU target in this field was given as an index and was set to 80 out of the emissions recorded in 1990, and in 2016 it amounted to 77, indicating the fact that this target was achieved at the EU level. Bearing in

mind the fact that there are no national targets set in this field, the average data can be used to assess the level of the differences amongst the countries. In that sense, a worrying fact that there are countries with the indicators significantly higher than the EU average, such as Cyprus (152.92), Spain (116.4), Portugal (115.8), and Ireland (113.4) should be highlighted.

The next indicator of sustainable growth is the share of renewable energy in the final energy consumption. It is evident from Fig. 2 that the highest differences amongst the Member States throughout the considered period were recorded in this indicator although they were significantly narrowed (first of all due to the significant progress made by the CEE and the Baltic States after the EU accession). The EU set the target for the year 2020 at the level of 20%, and in the year 2016, it reached 17%, but the insight gained into the group and the national data gives a completely different picture. The fact that the average indicator for the Core countries amounted to 29.4%, and for the Periphery countries only to 12.7%, maybe the best illustration of the situation in this field. In addition to the foregoing, if the fact that the best performer in this field, Sweden (53.8%), has a share almost 10 times as high as that of the worst performer, Luxembourg (5.4%), is taken into account, it is possible to conclude that there is significant room for making progress in this field in the future.

If primary and the final energy consumption are considered, it can be concluded that the differences in primary energy consumption increased, although still being lower in comparison to the final energy consumption, where the differences lowered during the period (Fig. 2). The targets for these indicators are given at the national level, but to compare the EU countries the authors calculated that the per-capita target amounted to 2.9 Mtoe for primary, and 2.1 Mtoe for the final consumption. Given at the EU level, the targets were achieved in 2016, but the group and the national level data again provide a better insight into the differences amongst the Member States. Average primary energy consumption per capita for the Core countries group amount to 3.6 Mtoe, and for the Periphery countries to 3.2 Mtoe, thus indicating the fact that the differences in this indicator are relatively low. However the fact that the best performer, Malta (1.5 Mtoe), has a consumption almost 5 times lower than that of the worst performer, Luxembourg (7.2 Mtoe), appears to be a bit worrisome. On the other hand, the national data are the best indicators in the case of the final energy consumption. The best performer in this field, Romania (1.1 Mtoe), is characterized by the final energy consumption, which is over 6 times as low as that of Luxemburg (6.9 Mtoe), as the worst performer.

Finally, the third pillar of the strategy is inclusive growth, which has been gaining in importance in the light of the sovereign debt and the migrant crisis. The progress made in this field is measured by the employment rate and people at risk of poverty or social exclusion. Fig. 2 unequivocally indicates the fact that the differences in the employment rate were the lowest during the period, whereas the differences in the other indicator were higher to a certain extent. The EU set out to achieve the employment rate amounting to 75% at the EU level in 2020, and it amounted to 71.1% in 2016, which is 94.8% of the target, thus making this target achievable by 2020. The average differences between the Core (73.4%) and the Periphery countries (68.3%) are relatively low. A relatively uniform situation in this field is best reflected by the fact that 9 countries have achieved their targets, whereas 16 of them have achieved over 90% of their national targets. When the average differences in the reduction of poverty are considered, it should be noted that they are relatively low, bearing in mind the fact that the average Core countries indicator has amounted to 19.7%, whereas the Periphery countries have recorded the average rate of 26.9%. If the fact that the EU target in this field is 22.5 % is taken into consideration, this target seems to be achievable. Generally observed, there are extremes, in this case, bearing in mind the fact that the best performer, the Czech Republic (13.3%), has an almost four times lower poverty rate in comparison with the worst performer, Bulgaria (40.4%).

5. Discussion

The Europe 2020 strategy is one of the key strategic frameworks for improvement of EU competitive position in the global market and achieving sustainable development in the near future. This is why assessment to progress in implementation of the strategy, which is primary goal of this paper, is very important issue. The efficient management of strategy implementation implies control of defined target meeting. The identification of mismatch between planned and achieved value of targets creates basis for implementation of some corrective measures in order to ensure full implementation of the strategy. However, in some cases it is pretty obvious that defined national targets probably will not be achieved until 2020, like those regarding the early school leavers in Malta and Romania, tertiary education in Romania, people at risk of poverty or social exclusion in Bulgaria, etc. Such cases can hamper the realization of the strategy goals at the EU level.

Generally observed, it can be concluded that the best results are recorded in achieving inclusive growth, having in mind that majority of EU Member

States approaching to defined targets in this area. This is the result of increased efficiency of EU social cohesion policy during the recent years. In the area of sustainable growth, considerable progress was made at the EU level in meeting all defined targets. However, there are still big differences between Member States in some aspects, especially in the area of renewable energy sources usage. According to obtained results, it seems that achieving the smart growth was the most difficult task to perform. The relative low level of R&D investments and unfavorable educational structure of population in large number of EU countries, especially in New Member States, limited the EU innovation potential and, consequently, its chances to improve its competitive position in the global market.

Sweden, Denmark and Austria kept their best performers status from previous years, as it was identified by Stec and Grzebyk (2018) and Fura et al. (2017), while Malta, Greece, Italy and Portugal continue to face with significant problems in strategy implementations among EU-15. In contrast to conclusions of Balcerzak (2015) that are based on data during the period 2009-2013, Germany and France recorded significant progress in the strategy implementation after 2013. These countries are classified as Core countries according to preformed ranking in this research for 2016, while Italy recorded rather modest progress and digress from Germany, France and most of EU-15.

New Member States have made considerable progress in the strategy implementation. Some of them boosted necessary reforms during the recent years and managed to approach to advanced EU-15, like Lithuania, Slovenia, Croatia and Czech Republic. Croatia was relatively poorly ranked in previous period, employed by Stec and Grzebyk (2018) and Fura et al. (2017). Thereupon the accession, Croatia has implemented some reforms aimed at achieving sustainable growth, which were followed by significant financial support from structural funds. Although the reforms aimed at achieving smart and inclusive growth were not so efficient, this country achieved considerable progress in strategy implementation, especially in comparison to Bulgaria and Romania that joined EU in 2007. Like in the previous period covered by other authors, these countries are still among the worst performers. These countries made some progress after accession, but the pace of reforms slowed down during the recent years.

6. Conclusion

The growing economic power of the US and China, predominantly driven by high R&D investments and the use of advanced technologies, has resulted in the domination of these two countries in the global market during

the last decade. In order to keep up with its major competitors, the EU has formulated a comprehensive plan for smart, sustainable and inclusive growth, which consists of the short-term measures aimed at overcoming the global economic crisis, on the one hand, and the long-term measures focused on the improvement of the competitive position of the European Union in the dynamic global environment, on the other.

In this study, the authors have evaluated the progress made in achieving the "Europe 2020" goals by applying the MULTIMOORA method and the Shannon Entropy Index. The application of the MULTIMOORA method has enabled the authors to conduct a comparative analysis of the EU countries by taking into consideration the nine headline indicators and to group them according to the level of the progress the countries have made in achieving the defined targets. On the other hand, the Shannon Entropy Index, usually used as a measure of inequality in regional analysis, was employed to assess the differences amongst the EU countries concerning the implementation of the individual strategic priorities.

The obtained results indicated that, in the year 2016, Sweden (ranked the 1st), Denmark (ranked the 2nd) and Austria (ranked the 3rd) were the best performing countries in the implementation of the "Europe 2020" Strategy. However, according to the results, it can be concluded that not all Old Member States have realized the importance of this strategy for the achievement of the long-term strategic goals, whereas amongst the New Member States there are the countries that top-prioritize this strategy (Lithuania, Slovenia, Croatia, and the Czech Republic). Generally observed, it can be noted that the majority of the EU countries have made some average progress in the strategy implementation, whereas Belgium (20th), Romania (20th), Italy (22nd), the Netherlands (22nd), Bulgaria (24th), Spain (25th), Cyprus (26th), Malta (27th), and Luxembourg (28th) were being faced with serious problems in achieving the strategic goals. This is the reason why these countries are classified into the group of Periphery countries.

When the evaluation of the progress made in the implementation of the strategic priorities by using the Shannon Entropy Index is concerned, the fact arises that the greatest differences have been recorded in the share of renewable energy in the final energy consumption with the highest value of the Shannon Entropy Index of 0.23, only to be followed by R&D expenditures (0.21), early school leavers (0.14), and the final energy consumption (0.13). It is possible to conclude that the EU countries were being faced with significant challenges in endeavoring to achieve smart and sustainable growth, whereas the majority of them were relatively successful in achieving inclusive growth.

Such results indicate the fact that there is significant room for progress to be made in a future period, but the question is: Is there enough time for all necessary reforms? Any delay in the achievement of the defined goals in the defined time may lead to the widening of the development gap between the European Union and its major competitors. Bearing in mind the fact that the quality monitoring of progress can indicate the right course of action, it can be concluded that this research study is of great practical importance; hence, it gives a general view of the current state of affairs. In accordance with the obtained results, the authors may propose that the Periphery countries can apply for additional financial assets from the Cohesion Fund, or benchmark the practices from the Core countries.

In order to perform the monitoring of the strategy implementation, the authors will perform further analysis in the future, while the results obtained in this study can serve as the basis for the redirection of the strategy by the "Europe 2020" Steering Committee (ESC) and the National ESCs. For further research, it is necessary to obtain the most actual data for all of the considered indicators in the Eurostat database, having in mind the fact that the significant limitation of this study is a lack of all the indicators for 2017 or 2018. The authors hope that by joining the research community dealing with the assessment of progress towards the "Europe 2020" strategy targets the results of this research will trigger further research in this important issue and create the basis for new ideas for investigating this topic, especially in a methodological sense. The novelty of this research study, first of all, lies in the introduction of the Shannon Entropy Index into this research field, which was primarily used in regional development studies. The introduction of this index has enabled a parallel investigation of progress both at the level of the country and at the level of the strategic priority.

In the future, it would be important to pay special attention to the prevention of the impact of current internal challenges (first of all the migrant crisis and Brexit) on the implementation of the "Europe 2020" strategic priorities. Also, the obtained results should raise policymakers' awareness about the importance of boosting smart and sustainable growth in the era of pronounced ecological problems, such as global warming and climate change. Namely, the cleaner production is impossible without a greater exploration of the innovation potential and, in that sense, without a greater application of technical and technological solutions in manufacturing processes. The development and introduction of the practices aimed at an environmental improvement into industrial processes will contribute to the prevention of the air, water, and land pollution and the minimization of risks

to humans in the EU, as well as at the global level. An increase in environmental standards in the EU is important for the improvement of the ecological situation, and protection and management in accession countries since they also have to meet the standards in this field if they want to become the members of this regional integration.

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Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Highlights:

- The MULTIMOORA method was applied for ranking and classification.
- The Shannon Entropy Index indicate the gap among EU countries in each strategy area.
- Sweden, Denmark and Austria are the best performers in strategy implementation
- Malta, the Netherlands, and Romania are positioned at the very end in the rankings
- The gaps in development of renewable energy production are the highest.