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COMPARATIVE ASSESSMENT OF ECONOMIC DEVELOPMENT IN THE COUNTRIES OF THE EUROPEAN UNION

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Abstract. Investment, the entry of foreign firms depends of a large extent on the country's goodwill, which is reflected in various ratings. This representation of the situation is approximate, as it does not estimate the differences between the values of the indicators with adjacent grades. This can be avoided by dividing countries into homogeneous groups. It is appropriate to do so on the basis of non-linear grouping rather than linear grouping. It is based on the transformation of data into a dimensionless scale and linear grouping. In the case, its homogeneity increases thanks to the levelling of the most distinctive values and the alignment of the statistical characteristics of the groups. The aim of the article is to propose in principle, a new approach to the ranking of countries on the basis of their level of economic development. It was found that the nonlinear decision of countries into homogenous groups and compared to the linear grouping more accurately reflect the current situation.

Keywords: economic development, gross domestic product, Harrington curves, non-linear grouping, interval compilation, homogenous group of countries.

JEL Classification: O10.

Introduction

An essential feature of the world around us is the increase in the scale, dynamics and diversity of information flows. In order to use it effectively for analysis, evaluation, management of development processes, it needs to be formalised. This makes it possible to reveal the characteristics, characteristics, features, of the meanings in question, which, by their very nature, become criteria. When they are expressed quantitatively, we get the indicators. The

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indicators reflect primary data. By combining indicators expressed in the same units of the measure into a single aggregate size, indexes are obtained. Both indicators and indices can measure the various aspects of the development of the countries – economic, social, ecological, cultural, etc. Indicators and indices also play a key role in the various types of ranking, including the countries. In the context of globalisation, information on country ratings in one aspect or another is of paramount importance as it is the basis for strategic decisions by the institutions concerned; external investment flows, international contracts, the creation of branches of foreign companies.

In this situation, the question of the adequacy of ratings becomes important, both scientifically and in practical terms. The analysis shows that the comparison among parties in one aspect of grade aid is misleading as the current situation is only approximate, distorted. This can be illustrated by the example of the European Union (EU) countries. Luxembourg's domestic gross product per capita (GDP) in 2019 was as high as 41.5% higher than in Ireland, Ireland 35.4% higher than Denmark, Denmark 13.4% higher than the Netherlands, while Germany's GDP was only 0.2% higher than in Belgium, Estonia only 0.4% higher than in the Czech Republic, Slovakia also only 0.4% higher than Greece (UNCTAD, 2021). In the meantime, Luxembourg ranked 1, Ireland 2, Denmark 3, the Netherlands 4, Germany 8, Belgium 9, Estonia 17, Czech Republic 18, Slovakia 21, Greece 22, i.e. regardless of the difference in values among their ranks. This shows that we also need to look for other, more adequate, country rankings.

The aim of the article is to propose, in principle, a new approach to the ranking of countries on the basis of their level of economic development.

In order to achieve it, the literature review analyses the sources that provide indicators of economic development in the countries, as well as the way in which they are ranked today. The study methodology shows how to determine the adequacy of today's generally applicable ranking of countries on the basis of the grades.

The empirical part of the article, based on the proposed methodology, presents and compares the results of the linear and non-linear grouping of the countries of the European Union in terms of economic development. The discussion describes the practical benefits which can be given to groups of countries rather than grades. The conclusions presented the main results of the article, as well as the directions of further investigations and their limitations.

An original methodology was proposed to increase it on the basis of a non-linear grouping of countries into homogeneous groups. The empirical part of the article demonstrates that the ranking of countries based on grades is inadequate and, according to the proposed methodology, EU countries are grouped according to adjacent grades with differences in indicator values. The options and directions for further studies, as well as possible limitations on them, are indicated.

1. Literature review

In the global context of internationalisation and globalisation, cross-country comparisons are becoming increasingly important. It is in the context of other countries that the real situa-

tion of the country taken individually becomes clear. Generally accepted and probably the only way to compare them today is ranking. Given that a country's rating may influence its development factors such as investment, goodwill, etc., it is essential to adequately identify the positions of the parties vis-à-vis each other. The extent of its application, and therefore its importance, can be illustrated by the example of foreign direct investment (FDI). In the context of a market economy, they play a crucial and crucial role in the economic development of many countries (Cicea & Marinescu, 2021; Oh & Kim, 2018; Sarkodie & Strezov, 2019; Wang et al., 2019). This is particularly true for EU Member States, which are significantly lagging behind the developed (Burns et al., 2017) members of the Community. In some cases, they increased their FDI revenues by more than 50%. (UNCTAD, 2021). An increase of 1% of GDP in foreign direct investment increases from up to % of GDP (Baiashvili & Gattini, 2020).

The scale of FDI directly depends on the country's attractiveness from the perspective of potential investors (Kozlova & Collan, 2020; Rodionov et al., 2021; Godlewska-Majkowska & Komor, 2021; Ly et al., 2018). It is a complex size that combines many indicators within itself. The most frequently mentioned are: GDP, competitiveness, corruption, labour market, tax policy (Samborskyi et al., 2020; Maza & Villaverde, 2015; Bayar et al., 2020). Potential investors, when choosing the country of investment, compare all these indicators with each other by ranking them. At the same time, the parties are rated. Aggregate rank and final investment decision (Lahrech et al., 2020; Golubeva, 2020; Groh et al., 2018; Saisana et al., 2020; Kearney, 2021). For example, country ranks by GDP can be found in Eurostat's information, corruption index reflects Corruption Perception Index, the understanding of happiness – Happiness index, the development of humanbeing – Human Development Index, income irregularity – Gini Coefficient and on… Countries are ranked according to their income. Its shows Country Classification Income Level Index.

Gross domestic product per capita is perhaps the main indicator of the country's attractiveness in terms of FDI, and it makes the sense to determine the extent to which it affects them. This can be done on the basis of the following correlation-regressive analysis model:

$$P_j = f\left(BVP_j\right), \tag{1}$$

where P_j is the country's foreign direct investment, net inflows (% of GDP); GDP_j – country's gross domestic product per capita.

The EU countries with significantly lower GDP (Romania, Bulgaria, Baltic countries) compared to developed countries were selected. Based on the (1) equation it is shown that correlation relations are realty similar ($r = 0.88$). On the other Land, in economically developed countries, such as Ireland, Denmark, Belgium, Germany, and so on, GPD doesn't have the influence in FDI ($r = 0.27$). It means that because of high regiments while entering the market the high technological level of investors enter the market is not economically correct. It is much simple to invest is to less economically developed countries, where labor force is cheap, the competitive level is high. Thus, the country's rating is a very important indicator, both strategic and political, on which the country's further development depends to a large extent, and it is therefore essential to adequately identify the situation of the countries in relation to each other in this respect. The objective of the article is a comparative assessment

of the economic development of countries, so the first step is to use an indicator reflecting it. This depends on two essential elements: a properly selected criterion against which countries are compared and the way in which they are compared.

Quantitative assessment of the state of economic development of the countries. The countries' development efforts are primarily geared towards economic development, an essential condition for people's well-being. It is therefore important, from a scientific and practical point of view, to adequately assess the level achieved. The choice of the indicator reflecting it is difficult for several reasons. In particular, it is by nature complex because it combines development factors such as technological progress, labour and financial markets, infrastructure, investment (Oželienė, 2019; Gedvilaitė, 2019; Boggia & Cortina, 2010; Molly, 2018; Jia et al., 2017; Li et al., 2018). On the other hand, its structure must be universally accepted in order to allow comparisons among countries. Its meaning must be understandable and information about it easily accessible. It is in this context that the proposed indicators of economic development of the countries need to be compared. The analysis of literature sources shows that there is a very large number of proposals to measure economic development in countries, but there is no consensus. All of them can be relatively divided into two groups. The first ones are those who provide a set of indicators. Representatives of the second study group combine part of these indicators into a single aggregate size (Figure 1).

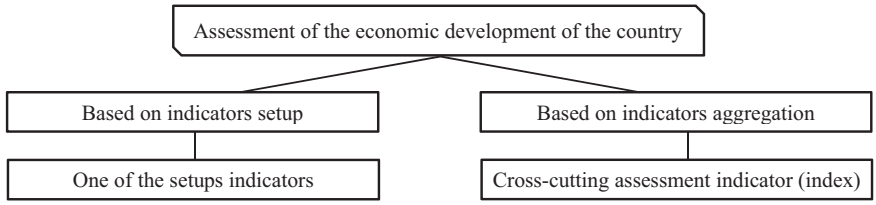

Figure 1. Indicators for the quantification of countries' economic development (source: drawn up by the author)

Figure 1 allows for a more detailed analysis of existing proposals. The set of indicators on the basis of which it is proposed to assess a country's EP differs in complexity, some being fewer and others more detailed. The former can be viewed as components of economic development, which, in their sense, form the basis of a country's economic activity. The following formation shall be indicated: labour, technology, infrastructure, financial capital, leadership (Šimelevič & Bagdzevičienė, 2001). Other studies provide a much broader set of EP indicators. In one case, for example at company level, it is proposed to reflect economic development by the following elements: economic results (30%), product quality (20%), output (15%), investment (15%), financing of socially responsible activities (10%), supply chain management (10%) (Juščius & Griauslytė, 2014). Otherwise, these include globalisation and conversion of production, innovation, competitiveness (Garbie, 2014), production costs (Lu, 2017; Huang, 2017), product quality, response time to product development (production) orders (Singh, 2016), cash flow (income, expenses, taxes, wage bills, arrears) (Slaper & Hall, 2011; Tan et al., 2015; Hasan et al., 2017). Many literature suggests a highly detailed set of indicators of economic development (Gedvilaitė, 2019).

Summarising the proposals for a quantitative assessment of the economic development of the first group of countries, all of them, ranging from the EP components to the primary indicators, are characterised by the same disadvantage, which do not allow a generalised picture of development. This is because they reflect the nuances of the EP, as a high degree of complexity, only individual, local, nuances. It was proposed how to get out of this situation – take the one that is characterised by the greatest complexity of (Chursan, 2013) from the number (Gedvilaitė, 2019; Bolcarova & Kološta, 2015; Babu & Datta, 2015) of indicators as representative.

In the second group of research, some of the indicators reflecting the EP are being combined into a single aggregate size, thus making an integrated assessment of the state of development (Čiegis et al., 2011; Radovanović & Lior, 2017; Jia et al., 2017; Bolcarova & Kološta, 2015; Chursan, 2013; Babu & Datta, 2015; Gedvilaitė, 2019).

Their analysis showed that in one case the economic development of the countries was analysed on the basis of 12 indicators, the second on the (Bolcarova & Kološta, 2015) basis of 10 indicators, the third (Jia et al., 2017) on the basis of 9, and (Radovanović & Lior, 2017) the fourth on the basis of 3 (Chursan, 2013; Babu & Datta, 2015). Thus, the number of indicators ranges from 3 to 12. In addition, their different formations, the way in which they are aggregated, the high cost of calculations due to the involvement of experts and the obtaining of primary values of the indicators, etc.

The analysis of the ways in which countries' economic development is quantified leads to a number of conclusions. Firstly, today there is no such indicator that would be universally accepted as an adequate indicator for the national EP. Secondly, the indicators taken individually reflect only local aspects of economic development, so their complexity does not correspond to the complexity of the EP phenomenon and therefore cannot adequately reflect the level of EP reached. Thirdly, the models of integrated assessment of development are imperfect, incomplete, as evidenced by their abundance, and therefore cannot adequately reflect the current level of economic development in a country. In this situation, it is appropriate to follow the principle of "receiving the best of all evils". To this end, all proposals need to be assessed in the context of the national EP indicator requirements.

For the reasons presented above, it is practically impossible to measure the economic development of countries by means of a single aggregate of a number of sub-indicators. There is another way used exclusively today – to take an indicator which, by its complexity, is most close to the complexity of the phenomenon under consideration, i.e. the country's economic development. It is a gross domestic product per capita. For international comparisons, despite its limitations, it is appropriate because it is calculated on the basis of a uniform methodology and information about it is easily accessible.

The ranking of the countries on the basis of the values of the indicator under consideration. The ranks of the parties have a multifaceted function: the public, scientists and interested instances are informed of the positions they hold in relation to each other, both in relation to each other. Such information is important as it can influence both political and economic strategic decisions, as well as shape the country's image. Trust in a country as a partner, the scale of investment, the entry of foreign firms into domestic markets, international contracts, etc. may depend on this.

The information needed to rank the parties is provided by various databases. One of them is specialised and the other is of a general nature. The first ones include: The World Bank Open Knowledge Repository, NATO e-library, JMF eLIBRARY, JAEA Library, UNiLibrary, International Financial and Credit Risk Management Database, electronic billing database. A number of such databases are available in the field of science – EBSCO Publishing, Taylor & Francis Online, Emerald, Web of Science, Scopus. The most popular database is Eurostat.

On the basis of the information provided by these and other databases, indicators are ranked across different areas of activity. For example, countries are ranked on the basis of the following indices: human Development Index (Human Development Index), Corruption Perception Index, Anti-money laundering Index, Quality of Life Index, etc. On the other hand, the analysis shows that grades do not adequately reflect the real situation, i.e. the position of the parties vis-à-vis each other, so it makes sense to look for different ways of displaying it.

The key indicator for determining a country's prestige is its level of economic development. It is examined in the context of three key interrelated criteria: changes, growth, improvement (Šimelevič & Bagdzevičienė, 2002). In additional to economic development, economic growth is also distinguished. This concept refers to an increase in the volume of production and services provided over a given period. This increase is reflected in the positive development of the real GDP indicator. Economic growth is at the heart of economic development. Thus, economic development is a broader concept and in addition to economic growth, includes also structural changes that lead to the creation of people's well-being, improvement of quality of life (Ganić & Hrnjic, 2019; Younsi & Bechtini, 2019; Ouechtati, 2020; Avetisyan, 2020). In this context, it is appropriate to examine the adequacy of the counties' situation through grading, in particular on the basis of their economic development.

2. Test methodology

When selecting a country's economic development indicator, it is necessary to follow its requirements: complexity, universally accepted structure, easy-to-understand meaning, easily accessible information. In this context, both options in Figure 1 need to be analysed. One of them is the formation of a complex indicator by combining partial indicators into a single aggregate size. It has to be abandoned for the following reasons: the content and number of system indicators and the way in which they are combined, the high cost of calculations, the difficulty of obtaining primary information on the values of the indicators are not generally approved. There is another way to pick from the proposed indicators the one that best meets the requirements. Gross domestic product per capita is most frequently mentioned and used. This is not an accident. Of all possible indicators, it has the highest degree of complexity and therefore adequately reflects the fundamental aspects of the country's economic development; the calculation is based on a uniform methodology and therefore allows comparisons among countries; information about it is regularly provided by international databases, making it easily accessible. In addition, almost all authors put it into the system of indicators of economic development in the countries. On this basis, the analysis will be carried out on the basis of this indicator.

The following model of correlation-regression analysis is used to determine the adequacy of the economic development of the countries by graded economic development:

$$R_i = f\left(\Delta BVP_i\right), \tag{2}$$

where R_i rank of economic development of the country; ΔBVP_i – the importance of economic development, measured by countries R_i and R_{i+1} grades.

If the connection proves unnecessarity, the ranks do not adequately reflect the situation and need to look for other ways of displaying it. One of these is the grouping of countries based on indicator values. In this way, it is possible to form homogeneous groups of them and to better reflect the current situation.

Statistics can be grouped in two ways, based on a fixed number and when they are not known. In the first case, the group size or range D may be determined as follows (Tarka & Olszewska, 2018; Bąk et al., 2002):

$$D = \frac{BVP_{\max} - BVP_{\min}}{m}, \tag{3}$$

where the $BVP_{\max}$ GDP of the country for which it is the highest; $BVP_{\min}$ – the same as for which it is the smallest, m – number of groups.

Where the size m is unknown, the number of groups shall be determined as follows:

$$\tilde{D} = \frac{BVP_{\max} - BVP_{\min}}{1 + 3{,}322\ \log N}, \tag{4}$$

where $\tilde{D}$ – the size of the interval; N – number of parties concerned.

The formulas (2) and (3) show that they reflect the linear division of statistical data into groups. It gives only an approximate picture, since one or more significantly different values of the indicator can significantly influence the result of the grouping. This can be avoided by applying non-linear data grouping methods based on non-linear normalization (Ginevičius et al., 2021a).

In such a case, on the basis of functional dependencies, existing, actual, values of the indicator in question are transformed into a dimensionless scale. The expression of such dependence may be as follows (Trishch & Slityuk, 2006; Ginevičius et al., 2021b):

$$Y_i = F\left(X_i^{'}\right) = \frac{\exp\left[-\exp\left(-X'\right)\right] + \left\{1 - \exp\left[-\exp\left(-X'\right)\right]\right\}}{2}, \tag{5}$$

where Y_i i means the value of the GDP of that country in a dimensionless scale; $X_i^{'}$ – the value of the GDP of the country I in the intermediate scale.

Dependency represents the asymptotic distribution of the random values of the median values of the statistical population. It is monotonous in nature with fracture points, the number of which depends on how many groups are. For example, if they are three, there will be two break points: $Y_1 = 0.37$ and $Y_2 = 0.63$ (Figure 2).

Values in Figure 2 X – axis tied to Y axis:

$$X' = -\ln\left(-\ln Y\right), \tag{6}$$

here, ln is a natural logarithm. For example, $Y' = \ln\left(-\ln 0.63\right) = 0.772398 \approx 0.77$ and $Y' = \ln\left(-\ln 0.37\right) = 0.005 \approx 0$.

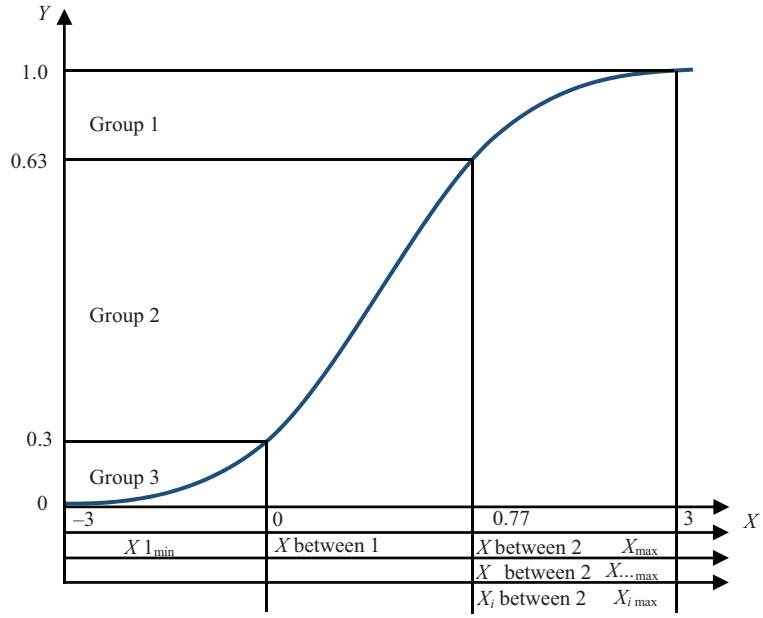

Figure 2. Graphoanalytical model for the division of the statistical population into three groups (source: Trishch & Slityuk, 2006)

The practical application of the model shown in Figure 2 is carried out in three stages. The first sets the maximum and minimum values for the indicator in question. In the second, its intermediate values $X_{i\ \text{between.}}$ If divided into three groups, there will be two. They shall be determined on the basis of formula (1). Finally stage, the partial data scale X_i is identified with the intermediate scale X'. For this purpose, the method of dividing the sections into equal proportions can be applied:

$$X' = \frac{X'_k + \gamma X'_d}{1+8}, \tag{7}$$

where the beginning of the X'_i i-th interval on the scale X_i; X'_d the same, the end.

The size γ shall be determined as follows:

$$\gamma = \frac{X_{ik} - X_i}{X_{ir} - X_{id}}, \tag{8}$$

where X_{ir} is the real value of this indicator on the scale X_i.

On the basis of this methodology, the countries of the European Union are grouped according to their economic development.

3. Empirical study of results

On the basis of the methodology set out above, a grouping of the European Union countries according to their economic development (GDP) was carried out in 2019, both linear and non-linear. Baseline data are given in Table 1.

Table 1. EU countries' gross domestic product per capita in 2019, thousand. Euro (source: UNCTAD, 2021)

Order No:	Country	GDP per capita	Rank	GDP difference between adjacent grades	
				Euro	%
1	Luxembourg	102.20	1	–	–
2	Ireland	72.26	2	29.6	40.8
3	Denmark	53.37	3	19.2	36.0
4	Netherlands	46.88	4	6.5	13.9
5	Sweden	46.39	5	0.5	1.1
6	Austria	44.78	6	1.6	3.6
7	Finland	43.51	7	1.3	3.0
8	Germany	41.51	8	2.0	4.9
9	Belgium	41.46	9	0.05	0.2
10	United Kingdom	37.83	10	3.7	9.8
11	France	36.14	11	1.7	4.7
12	Italy	29.98	12	6.1	20.4
13	Malta	26.92	13	3.1	11.6
14	Spain	26.43	14	0.5	1.9
15	Cyprus	25.27	15	1.1	4.4
16	Slovenia	23.17	16	2.1	9.1
17	Estonia	21.22	17	2.0	9.5
18	Czech	21.14	18	0.1	0.5
19	Portugal	20.80	19	0.3	1.5
20	Lithuania	17.47	20	3.3	18.9
21	Slovakia	17.22	21	0.3	2.4
22	Greece	17.11	22	0.1	0.6
23	Latvia	15.43	23	1.2	7.6
24	Hungary	14.95	24	0.9	6.0
25	Poland	13.90	25	1.1	12.8
26	Croatia	13.34	26	0.6	4.6
27	Romania	11.51	27	1.8	15.7
28	Bulgaria	8.78	28	2.7	30.7

In particular, the ranges, the sizes and the number of countries covered were established on the basis of formulas (2) to (7) (Table 2).

Table 2 shows that the results of linear and non-linear grouping differ between the ranges and the size and the number of countries covered.

According to Table 2, EU countries are grouped (Table 3).

The question arises about the appropriateness of non-linear grouping compared to linear. There is no answer yet and cannot be. This can be explained by analogy with multi-criteria assessment. There are a lot of his methods, because there is no ideal option.

Table 2. Comparison of the linear and non-linear grouping of European Union countries according to their development in 2019 (source: drawn up by the author)

Groups of countries	Method of grouping countries															
	linear								non-linear							
	number of buckets specified				based on Stredgess formula				number of buckets specified				based on Stredgess formula			
	the size of the ranges	range ranges		number of countries	the size of the ranges	range ranges		number of countries	the size of the ranges	range ranges		number of countries	the size of the ranges	range ranges		number of countries
		from	by:			from	by:			from	by:			from	by:	
First	21.27	51.34	72.61	3	10.63	61.95	72.60	2	19.21	54.75	73.96	2	11.99	65.35	76.34	2
Second	21.27	30.07	51.34	8	10.63	51.32	61.95	1	21.27	33.48	54.75	9	11.09	54.26	65.35	0
Third	21.27	8.8	30.07	17	10.63	40.69	51.32	6	24.68	8.8	33.48	17	11.19	43.07	54.26	5
Fourth	Total			28	10.63	30.06	40.69	2	Total			28	11.30	31.77	43.07	4
Fifth					10.63	19.43	30.06	8					11.42	20.35	31.77	8
Sixth					10.63	8.80	19.43	9					11.55	8.80	20.35	9
					Total			28					Total			28

Table 3. Grouping of European Union countries according to their economic development in 2019 (source: drawn up by the author)

Groups of countries by type of grouping								
linear								
based on the number of ranges indicated			based on Stredgess formula					
first	second	third	first	second	third	fourth	fifth	sixth
Luxembourg	Netherlands	Italy	Luxembourg	Denmark	Netherlands	United Kingdom	Italy	Lithuania
Ireland	Sweden	Malta	Ireland		Sweden	France	Malta	Slovakia
Denmark	Austria	Spain			Austria		Spain	Greece
	Finland	Cyprus			Finland		Cyprus	Latvia
	Germany	Slovenia			Germany		Slovenia	Hungary
	Belgium	Estonia			Belgium		Estonia	Poland
	United Kingdom	Czech					Czech	Croatia
	France	Portugal					Portugal	Romania
		Lithuania						Bulgaria
		Slovenia						
		Greece						
		Latvia						
		Hungary						
		Poland						
		Croatia						
		Romania						
		Bulgaria						

End of Table 3

non-linear								
based on the number of ranges indicated			based on Stredgess formula					
first	second	third	first	second	third	fourth	fifth	sixth
Luxembourg	Denmark	Italy	Luxembourg		Denmark	Germany	Italy	Lithuania
Ireland	Netherlands	Malta	Ireland		Netherlands	Belgium	Malta	Slovenia
	Sweden	Spain			Sweden	United Kingdom	Spain	Greece
	Austria	Cyprus			Austria	France	Cyprus	Latvia
	Finland	Slovenia			Finland		Slovenia	Hungary
	Germany	Estonia					Estonia	Poland
	Belgium	Czech					Czech	Croatia
	United Kingdom	Portugal					Portugal	Romania
	France	Lithuania						Bulgaria
		Slovenia						
		Greece						
		Latvia						
		Hungary						
		Poland						
		Croatia						
		Romania						
		Bulgaria						

This is also the case in the case of grouping, i.e. that there is no ideal (if at all possible) method of grouping until we can unequivocally answer the question of the accuracy of existing methods. The fact that the non-linear grouping is more precise than the linear one can be inferred from the fact that, in the first case, the ranges are different, i.e. they "response" to the difference among adjacent values. Meanwhile, in the case of linear grouping, the statistical sample is simply mechanically divided into the selected number of ranges and therefore their size is the same.

The adequacy of the linear grouping can be verified on the basis of the following model of correlation (1) analysis (Table 1).

The calculations showed that there is ΔQ_j almost no relationship between R_j and (r = 0.154). This confirms the claim that the comparison among the parties on the basis of grades is inadequate and that different approaches to the comparison among the parties are necessary.

The results obtained in the article, their meaning, can be commented on in two respects. The first is that a new approach to country ranking has been proposed. Today's high rating at the same time means the country's high international prestige. In our case, a high GDP indicator, reflecting economic development, makes the country attractive to potential investors.

The article demonstrates that today's generally applicable ranking of countries on the basis of grades is inadequate. As a result, some of them are unprofitable and others are being undermined. The proposed solution to this situation is to reflect the situation of the countries in a homogeneous way in terms of the value of the indicator in the groups of countries rather than grades. This solves the problem of rating adequacy.

In this direction, there is a problem, both in practice and in theory, of an adequate division of countries into groups. Today, this problem has not been resolved, as mechanical increases are proposed and presented, i.e. when all groups are of the same size. This is the so-called linear grouping. Meanwhile, in real life everything happens in a non-linear way. The article proposes a methodology for the non-linear grouping of the statistical population, which has been successfully adapted to divide EU countries into groups according to their level of economic development.

In order to consolidate this methodology, it should be extended to other similar problems. This is possible because the methodology is universal. Its meaning is increasing as the volume of the statistical population increases.

On the other hand, it can be assumed that the effectiveness of its application may be reduced if the statistical population is very homogeneous, i.e. when the values of all the indicators with adjacent ranks are very close. All this must be demonstrated by future research.

Conclusions

In the context of globalisation, comparisons among countries in one aspect or another are of particular importance, as this is the basis for strategic development decisions, which influences investment flows, contracts, the entry of foreign firms into the country, etc. These comparisons are carried out when the countries are ranked. Grades are awarded depending on the values of the indicator that reflects the aspect under consideration. In assessing the importance of ranking, it is important that the parties' ranking is adequate, i.e. conveying a true picture. The analysis shows that grading on the basis of contiguous values only repre-

sents a rough, sometimes even misleading, situation. This is because the countries, regardless of whether the values of the indicator in question are almost the same (difference in 100 ths) or tens of percent, still acquire adjacent ranks.

Another, more adequate way of ranking is to convey the current situation to homogeneous groups of countries rather than grades. On the other hand, there is a problem of the adequacy of grouping countries. Today, linear grouping is exclusively applied, i.e. the statistical sample is mechanically divided into a selected number of groups. In this case, countries with almost the same indicator values can be found in different groups, and vice versa, countries with significantly different indicator values will be in the same group. The possibility of such a situation is confirmed by the results of the correlation analysis. They showed that there is practically no link in the difference between the economic development grade granted to the country and the values measured in adjacent grades. ($R = 0.154$).

The application of the proposed methodology may be limited by the difficulties associated with the reorganization of international databases. They should convey the situation of countries not by rank but by homogeneous groups. Further research should reveal the inadequacy of conveying the states of the countries not only in economic development but also in other areas.

References

Avetisyan, A. (2020). Country attractiveness: Analysis of the main factors. *Finance: Theory and Practice*, *24*(4), 58–74. https://doi.org/10.26794/2587-5671-2020-24-4-58-74

Babu, S., & Datta, S. (2015). Revisiting the link between socio-economic development and environmental status indicators focus on panel data. *Environment Development and Sustainability, 17*(3), 567–586. https://doi.org/10.1007/s10668-014-9561-6

Baiashvili, T., & Gattini, L. (2020). *Impact of FDI on economic growth: The role of country income levels and institutional strength* (EIB Working Paper 2020/02). European Investment Bank.

Bąk, I., Markowicz I., Mojsiewicz, M., & Wawrzyniak, K. (2002). *Statystyka w zadaniach (część I).* [Statistics in tasks]. Wydawnictwa Naukowo Techniczne (in Polish).

Bayar, Y., Remeikiene, R., Androniceanu, A., Gaspareniene, L., & Jucevicius, R. (2020). The shadow economy, human development and foreign direct investment inflows. *Journal of Competitiveness*, *12*(1), 5–21. https://doi.org/10.7441/joc.2020.01.01

Boggia, A., & Cortina, C. (2010). Measuring sustainable development using a multi-criteria model: A case study. *Journal of Environmental Management*, *91*(11), 2301–2306. https://doi.org/10.1016/j.jenvman.2010.06.009

Bolcarova, P., & Kološta, S. (2015). Assessment of sustainable development in the EU 27 using aggregated SD index. *Ecological Indicators*, *48*, 699–705. https://doi.org/10.1016/j.ecolind.2014.09.001

Burns, D. K., Jones, A. P., Goryakin, Y., & Suhrcke, M. (2017). Is foreign direct investment good for health in low and middle income countries? An instrumental variable approach. *Social Science & Medicine*, *181*(C), 74–82. https://doi.org/10.1016/j.socscimed.2017.03.054

Chursan, S. (2013). Assessing the sustainable development in Thailand. *Procedia. Environmental Sciences*, *17*, 611–619. https://doi.org/10.1016/j.proenv.2013.02.077

Cicea, C., & Marinescu, C. (2021). Bibliometric analysis of foreign direct investment and economic growth relationship. A research agenda. *Journal of Business Economics and Management*, *22*(2), 445–466. https://doi.org/10.3846/jbem.2020.14018

Čiegis, R., Ramanauskienė, J., & Šimanskienė, L. (2011). *Lietuvos regionų darnaus vystymosi vertinimas* [Sustainable development assessment of Lithuanian regions]. Klaipėdos universiteto leidykla (in Lithuanian).

Ganić, M., & Hrnjic, M. (2019). Does a country's business regulatory environment affect its attractiveness to FDI? Empirical evidence from Central and Southeast European countries. *Eastern Journal of European Studies, 10*(2), 89–105.

Garbie, I. (2014). An analytical technique to model and assess sustainable development index in manufacturing enterprises. *International Journal of Production Research*, *52*(16), 4876–4915. https://doi.org/10.1080/00207543.2014.893066

Gedvilaitė, D. (2019). *The assessment of sustainable development of a country's regions* [Doctoral dissertation]. Technika. http://dspace.vgtu.lt/bitstream/1/3797/1/Gedvilaite%20disertacija%2005%2016nn.pdf

Ginevičius, R., Szczepańska-Woszczyna, K., Szarucki, M., & Stasiukynas, A. (2021a). Assessing alternatives to the development of administrative-economic units applying the FARE-M method. *Administratie si Management Public*, *36*, 6–24. https://doi.org/10.24818/amp/2021.36-01

Ginevičius, R., Trishch, R., Remeikienė, R., & Gasparėnienė, L. (2021b). Complex evaluation of the negative variations in the development of Lithuanian municipalities. *Transformations in Business & Economics*, *20*(2A(53A)), 635–653.

Godlewska-Majkowska, H., & Komor, A. (2021). Energy as a factor of investment attractiveness of regions for agricultural enterprises. *Energies*, *14*(9), 2731. https://doi.org/10.3390/en14092731

Golubeva, O. (2020). Maximising international returns: Impact of IFRS on foreign direct investments. *Journal of Contemporary Accounting & Economics, 16*(2), 100200. https://doi.org/10.1016/j.jcae.2020.100200

Groh, A., Liechtenstein, H., Lieser, K., & Biesinger, M. (2018). *The venture capital and private equity country attractiveness index 2018* (9th ed.). IESE Business School University of Navara. http://blog.iese.edu/vcpeindex/files/2018/02/report2018.pdf

Hasan, M., Ebrahim, Z., Wan Mahmood, W., & Ab Rahman, M. (2017). Sustainable-ERP system: A preliminary study on sustainability indicators. *Journal of Advanced Manufacturing Technology (JAMT)*, *11*(1), 61–74.

Huang, A. (2017). *A framework and metrics for sustainable manufacturing performance evaluation at the production line, plant and enterprise levels* [Doctoral dissertation]. University of Kentucky. https://doi.org/10.13023/ETD.2017.373

Jia, X., Foo, D. C. Y., Tan, R. R., & Li, Z. (2017). Sustainable development paths for resource-constrained process industries. *Resources, Conservation and Recycling*, *119*, 1–13. https://doi.org/10.1016/j.resconrec.2016.11.004

Juščius, V., & Griauslytė, J. (2014). Lietuvos įmonių socialinės atsakomybės ataskaitų taikymas verslo praktikoje [Application of social responsibility reports of Lithuanian companies in business practice]. *Organizacijų vadyba: sisteminiai tyrimai*, *69*, 55–70 (in Lithuanian). https://doi.org/10.7220/MOSR.1392.1142.2014.69.4

Kearney. (2021). *The 2022 FDI Confidence Index.* https://www.kearney.com/foreign-direct-investment-confidence-index/2022-full-report

Kozlova, M., & Collan, M. (2020). Renewable energy investment attractiveness: Enabling multi-criteria cross-regional analysis from the investors' perspective. *Renewable Energy*, *150*(C), 382–400. https://doi.org/10.1016/j.renene.2019.12.134

Lahrech, A., Alabdulwahab, S. Z., & Bouayach, S. (2020). Nation branding and how it is related to foreign direct investment inflows. *International Journal of Economics and Financial Issues*, *10*(2), 248–255. https://doi.org/10.32479/ijefi.9345

Li, Z., Tang, D., Han, M., & Bethel, B. (2018). Comprehensive evaluation of regional sustainable development based on data envelopment analysis. *Sustainability*, *10*(11), 1–18. https://doi.org/10.3390/su10113897

Lu, W.-C. (2017). Greenhouse gas emissions energy consumption and economic growth: A panel cointegration analysis for 16 Asian countries. *International Journal of Environmental Research and Public Health*, *14*(11), 1436. https://doi.org/10.3390/ijerph14111436

Ly, A., Esperança, J., & Davcik, N. S. (2018). What drives foreign direct investment: The role of language, geographical distance, information flows and technological similarity. *Journal of Business Research*, *88*, 111–122. https://doi.org/10.1016/j.jbusres.2018.03.007

Maza, A., & Villaverde, J. (2015). A new FDI potential index: Design and application to the EU regions. *European Planning Studies*, *23*(12), 2535–2565. https://doi.org/10.1080/09654313.2015.1020771

Molly, K. M. (2018). Regional differences in Slovenia from the viewpoint of achieving Europe's sustainable development. *Acta Geographica Slovenia*, *58*(2), 2–46. https://doi.org/10.3986/AGS.3309

Oh, H. M., & Kim, W. Y. (2018). The effect of analyst coverage on the relationship between seasoned equity offerings and investment efficiency from Korea. *Sustainability*, *10*(8), 2704. https://doi.org/10.3390/su10082704

Ouechtati, I. (2020). Institutions and foreign direct investment: A panel VAR approach. *International Journal of Economic Sciences*, *9*(2), 55–70. https://doi.org/10.20472/ES.2020.9.2.004

Oželienė, D. (2019). *Modelling the factors of a company's sustainable development* [Doctoral dissertation]. Vilnius Gediminas Technical University.

Radovanović, M., & Lior, N. (2017). Sustainable economic–environmental planning in Southeast Europe – beyond-GDP and climate change emphases. *Sustainable Development*, *25*(6), 580–594. https://doi.org/10.1002/sd.1679

Rodionov, D. G., Konnikov, E. A., & Nasrutdinov, M. N. (2021). A transformation of the approach to evaluating a region's investment attractiveness as a consequence of the COVID-19 pandemic. *Economies*, *9*(12), 59. https://doi.org/10.3390/economies9020059

Saisana, M., Montalto, V., Neves, A., & Damioli, G. (2020). *Statistical audit of the 2020 Global Innovation Index*. Joint Research Centre (JRC). https://www.wipo.int/edocs/pubdocs/en/wipo_pub_gii_2020-appendix5.pdf

Samborskyi, O., Isai, O., Hnatenko, I., Parkhomenko, O., Rubezhanska, V., & Yershova, O. (2020). Modeling of foreign direct investment impact on economic growth in a free market. *Accouting*, *6*(5), 705–712. https://doi.org/10.5267/j.ac.2020.6.014

Sarkodie, S. A., & Strezov, V. (2019). Effect of foreign direct investments, economic development and energy consumption on greenhouse gas emissions in developing countries. *Science of The Total Environment*, *646*(1), 862–871. https://doi.org/10.1016/j.scitotenv.2018.07.365

Singh, S. (2016). *Development of Sustainable Manufacturing decision making modells for small and medium enterprises* [Doctoral dissertation]. University of Malaya.

Slaper, T. F., & Hall, T. J. (2011). The triple bottom line: What is it and how does it work? *Indiana Bussiness Review*, *86*(1), 4–8. https://www.ibrc.indiana.edu/ibr/2011/spring/article2.html

Šimelevič, K., & Bagdzevičienė, R. (2001). Kas yra regionas? [What is a region?]. In *Tarptautinės mokslinės konferencijos "Regionų plėtra 2001" pranešimų medžiaga"* (pp. 274–275). Technologija (in Lithuanian).

Šimelevič, K., & Bagdzevičienė, R. (2002). Regionalizacijos procesas – vienas iš svarbiausių veiksnių, užtikrinančių regionų ekonominę plėtrą [The process of regionalization as one of the most important factors ensuring the economic development of regions]. In *Tarptautinės mokslinės konferencijos "Regionų plėtra 2002" pranešimų medžiaga* (pp. 179–185). Technologija (in Lithuanian).

Tan, H. X., Yeo, Z., Ng, R., Tjandra, T. B., & Song, B. (2015). A sustainability indicator framework for Singapore small and medium-sized manufacturing enterprises. *Procedia CIRP*, *29*, 132–137. https://doi.org/10.1016/j.procir.2015.01.028

Tarka, D., & Olszewska, A. M. (2018). *Elementy statystyki. Opis statystyczny* [Elements of statistics. Statistical description]. Oficyna Wydawnicza Politechniki Białostockiej (in Polish).

Trishch, R. M., & Slityuk, E. A. (2006). Generalized point and interval evaluation items ICE workmanship [Obobshchonnaya tochechnaya i interval'naya otsenki kachestva izgotovleniya detali DVS]. *Eastern-European Journal of Enterprise Technologies*, *1/2*(19), 63–67.

UNCTAD. (2021). *World Investment Report 2021. Investing in sustainable recovery*. https://unctad.org/webflyer/world-investment-report-2021

Wang, L., Zhang, C., & Jiang, F. (2019). Matching governance mechanisms with transaction-specific investment types and supplier roles: An empirical study of cross-border outsourcing relationships. *International Journal of Business Review*, *28*(2), 316–327. http://hdl.handle.net/20.500.11937/73274

Younsi, M., & Bechtini, M. (2019). Does good governance matter for FDI? New evidence from emerging countries using a static and dynamic panel gravity model approach. *Economics of Transition and Institutional Change*, *27*(3), 841–860. https://doi.org/10.1111/ecot.12224