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CHOOSING APPROPRIATE ECONOMIC DEVELOPMENT INDICATORS - A MULTIVARIATE STATISTICAL APPROACH

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***Abstract*:** *Economic development of countries is a much discussed topic. Numerous researchers use variety of approaches to measure it, but they all agree that economic development is a multidimensional concept. Most common countries' rankings are based on their GDP. The aim of this paper is to present one synthesized indicator that is able to quantitatively demonstrate any country's economic development. The statistical I-distance method is thoroughly explained and applied to 28 European Union countries. Crucial ranking indicators are also elaborated.*
Keywords: *I-distance method, European Union countries, economic development*

INTRODUCTION

Different approaches are used to measure and evaluate economic development of countries, but they all agree that economic development is a multidimensional concept. Many researchers use various indicators, but most common rankings are done according to countries' GDP. However, this method cannot capture real inequalities among countries in terms of different and sometimes contrasting dimensions of well-being of their populations [1]; it is at best only a partial measure of economic development. Thus, in addition to GDP, the measurement of a country's economic development should include numerous indicators, while examining their importance at the same time. This research paper presents the multivariate I-distance approach which is applied on selected indicators that are synthesized into one value which thereafter represents a country's level of economic development.

THE I-DISTANCE METHOD

To create a synthesized economic development indicator, selected economic indicators are incorporated into the analysis through use of the statistical I-distance method. The analyses carried out using the statistical I–distance method are numerous. I–distance is applied in [2] and [3] to evaluate the academic ranking of the world's universities. It was also used in [4] for measuring European countries' health systems, sustainable development and public health [5] and ICT Development [6].

I–distance is a metric distance in an *n*–dimensional space. Ivanović [7] originally devised this method to rank countries according to their level of socio–economic development based on several indicators. In order to create a synthesized development indicator, selected variables are incorporated into one value that will thereafter represent the rank. Many socio-economic development indicators were considered and the problem was how to use all of them to calculate a single synthetic indicator, which would thereafter represent the rank.

For a selected set of variables $X^T = (X_1, X_2,\ldots, X_k)$ chosen to characterize the entities, the I-distance

between the two entities $e_r = (x_{1r}, x_{2r},\ldots, x_{kr})$ and $e_s = (x_{1s}, x_{2s},\ldots, x_{ks})$ is defined as

$$D(r,s) = \sum_{i=1}^{k} \frac{|d_i(r,s)|}{\sigma_i} \prod_{j=1}^{i-1} (1 - r_{ji.12\ldots j-1})$$

where $d_i\ (r,s)$ is the distance between the values of variable X_i for e_r and e_s e.g. the discriminate effect,

$$d_i\ (r,s) = x_{ir} - x_{is,}, \qquad i \in \{1,\ldots,k\}$$

σ_i standard deviation of X_i, and $r_{ji.12\ldots j-1}$ is a partial coefficient of the correlation between X_i and X_j, ($j<i$) [8].

The construction of the I-distance is iterative; it is calculated through the following steps:

- Calculate the value of the discriminate effect of the variable X_1 (the most significant variable that provides the largest amount of information on the phenomena that are to be ranked,
- Add the value of the discriminate effect of X_2 which is not covered by X_1,
- Add the value of the discriminate effect of X_3 which is not covered by X_1 and X_2,
- Repeat the procedure for all variables [9].

Occasionally, it is not possible to achieve the same sign mark for all variables in all sets. As a result, a negative correlation coefficient and a negative coefficient of a partial correlation may occur. This makes the use of the square I-distance even more desirable [10]. The square I-distance is given as

$$D^2(r,s) = \sum_{i=1}^{k} \frac{d_i^2(r,s)}{\sigma_i^2} \prod_{j=1}^{i-1} (1 - r^2_{ji.12\ldots j-1})$$

The entity with the minimal value for each indicator or a fictive maximal or average value entity can be set up as the referent entity. The ranking of entities

in the set is based on the calculated distance from the referent entity [11].

By using the calculated I^2-distance we can observe the intensity of the observed phenomena and the rank of entities. When a correlation coefficient of each indicator with the I^2-distance is calculated with the ranking indicators of these values, the importance of each indicator can also be examined. As the correlation coefficient is stronger, the amount of information that is provided with the observed indicator is also greater, when the $p < 0.05$ indicator is significant. Otherwise, the indicator is not important in measuring the observed phenomena. One of the two reasons might explain this: either this indicator is not relevant in measuring the observed phenomena, or its discriminate effect is already contained in previous variables. Whatever the reason, the indicator must be excluded from further analysis, since, to select only significant indicators, it is necessary to calculate the I^2-distance and its correlation with the indicators used several times, excluding one insignificant indicator that has the smallest correlation coefficient. Through the use of stepwise method, one indicator is eliminated in every calculation until the results show that all used indicators are significant, whereupon the results are obtained [12].

THE RESULTS

In order to examine the economic development of the EU countries and to propose a potential framework for measuring it, a data set of 28 EU countries were selected. The latest data available were obtained and officially proposed indicators of The World Bank were selected. The initial indicators of economic development are presented in Table I:

TABLE I.
THE INITIAL INDICATORS OF ECONOMIC DEVELOPMENT

Domestic credit to private sector (% of GDP)
Exports of goods and services (% of GDP)
Foreign direct investment, net outflows (% of GDP)
GDP per capita, PPP (current international $)
GDP growth (annual %)
Inflation, consumer prices (annual %)
Unemployment, total (% of total labor force)

The results achieved by the square I-distance ranking method in the first calculation for evaluating economic development are presented in Table II.

TABLE II.
THE RESULTS OF THE I^2-DISTANCE METHOD, I^2-DISTANCE VALUE, AND RANK – FIRST CALCULATION

Country	*I^2-distance*	*Rank*
Luxembourg	72.64	1
Estonia	35.85	2
Hungary	35.06	3
Lithuania	30.05	4
Latvia	28.64	5
Austria	28.63	6
Malta	25.38	7
Ireland	25.31	8
Poland	24.52	9
Slovakia	24.03	10
Romania	22.81	11
Germany	21.48	12
Czech Republic	20.56	13
Netherlands	20.00	14
Belgium	18.27	15
Bulgaria	17.98	16
United Kingdom	16.99	17
Sweden	16.42	18
Denmark	16.09	19
Finland	16.05	20
France	13.16	21
Croatia	12.79	22
Slovenia	11.14	23
Italy	10.54	24
Spain	9.69	25
Portugal	8.25	26
Cyprus	7.26	27
Greece	2.46	28

This data set was further examined and a correlation coefficient of each indicator with the I^2-distance value was determined. The results are presented in Table III (using the Pearson correlation test).

TABLE III.
THE CORRELATION BETWEEN THE I^2-DISTANCE AND THE INITIAL INDICATORS

Indicator	*r*
Exports of goods and services (% of GDP)	0.839**
Foreign direct investment, net outflows (% of GDP)	0.746**
GDP per capita, PPP (current international $)	0.558**
GDP growth (annual %)	0.482**
Unemployment, total (% of total labor force)	0.437*
Inflation, consumer prices (annual %)	0.302
Domestic credit to private sector (% of GDP)	0.184

** $p < 0.01$; *$p < 0.05$

The correlation coefficients between the I^2-distance and initial indicators demonstrate which indicators are important in analyzing a country's economic development. The stepwise method excludes one insignificant indicator with the smallest value of the correlation coefficient. Calculating the I^2-distance should be repeated stepwise until the results show that all selected indicators are statistically significant [12]. The results need not include all indicators that were significant in the first calculation, but may

include those indicators that were insignificant in first calculation. The results are presented in Table IV.

TABLE IV.
THE RESULTS OF THE I^2-DISTANCE METHOD, I^2-DISTANCE VALUE, AND RANK – LAST CALCULATION

Country	*I^2-distance*	*Rank*
Luxembourg	75.16	1
Austria	28.39	2
Estonia	27.46	3
Ireland	27.34	4
Latvia	24.57	5
Malta	24.47	6
Lithuania	21.36	7
Germany	21.19	8
Netherlands	17.49	9
Sweden	17.09	10
United Kingdom	15.54	11
Denmark	15.45	12
Slovakia	15.43	13
Poland	15.39	14
Hungary	14.54	15
Finland	14.28	16
Romania	13.32	17
Belgium	12.96	18
Bulgaria	12.91	19
Czech Republic	12.86	20
France	12.78	21
Spain	8.57	22
Slovenia	7.71	23
Italy	7.68	24
Portugal	6.81	25
Croatia	6.44	26
Cyprus	5.86	27
Greece	2.82	28

Once again, a correlation coefficient of each indicator was examined with the I^2-distance; the results are presented in Table V.

TABLE V.
THE CORRELATION BETWEEN I^2-DISTANCE AND FINAL INDICATORS

Indicator	*r*
Exports of goods and services (% of GDP)	0.835**
Foreign direct investment, net outflows (% of GDP)	0.797**
GDP per capita, PPP (current international $)	0.756**
Unemployment, total (% of total labor force)	0.507**
GDP growth (annual %)	0.402*

** $p < 0.01$; *$p < 0.05$

All the observed indicators from the last calculation are statistically significant, meaning that this is the final calculation of the last two tables presenting the results in examining economic development of the observed countries. As it can be seen, the most important indicator is Exports of goods and services (r=0.835, p<0.01).

Of the selected indicators, GDP per capita ranks 3rd in importance. Previous researchers [13] addressed the hypothesis that GDP per capita cannot be considered the only and crucial indicator of a country's economic development, as it does not capture the overall well-being of its population. This paper proves the hypothesis true, but also demonstrates that GDP is a very significant indicator (r=0.756, p<0.01).

Table V shows the final results of the I^2-distance Method, I^2-distance Value, and Rank. The highest value of I^2-distance belong to Luxembourg, which tops the list. In contrast to Luxembourg, ranked at the bottom of this list are countries with the lowest level of economic development – Croatia, Cyprus and Greece.

CONCLUSION

The I-distance method has been applied here to measure the level of economic development of a defined selection of countries based on different indicators. The research started with initial indicators. Through the use of stepwise method, several calculations led to the final set of indicators, which were then used to measure countries' economic development.

As the I-distance method is able to synthesize many indicators into one single numerical value that represents rank, not only can countries be ranked, but the differences between them can be better explored as well. This method can identify crucial indicators for measuring economic development of EU countries. Using correlation coefficients between the I^2-distance and the final set of indicators, importance of each indicator is evaluated. This approach could further prove useful in future research on the economic performance of the EU countries as well as other phenomena.

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