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Department of Economics and Physics, Technical University of Cluj-Napoca, Romania

# PROCEEDINGS

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**Edited by:**

***Assoc.Prof. Grațiela Dana BOCA, PhD***

***Prof. Cezar TOADER, PhD***

***DEPARTMENT OF ECONOMICS***
***TECHNICAL UNIVERSITY OF CLUJ-NAPOCA, ROMANIA***



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# ECONOMIC PERFORMANCE EVALUATION OF EUROPEAN UNION COUNTRIES BY TOPSIS METHOD

*Mahmut MASCA*
Afyon Kocatepe University, Turkey, mmasca@aku.edu.tr

**ABSTRACT**
*In this study, an economic performance evaluation of European Union (EU) Countries has been made by a TOPSIS (Technique for Order Priority of Similarity by Information System) method which is based on Multi Criteria Decision Making (MDCM) approach by six macro-economic data of 28 EU countries. The data belong to year of 2015. TOPSIS method has been applied for the ranking of the countries for 2015. To assess the performance of economies, six macro-economic indicators, four of which are Maastricht criteria are used: long-term interest rates, general government deficit (-) and surplus (+) (as percentage of GDP), general government gross debt (as percentage of GDP), inflation rate, gross fixed capital formation (as percentage of GDP) and unemployment rate. The results show that Sweden had best economic performance and Greece had the worst performance in 2015.*

**KEYWORDS:** *European Union, Maastricht Criteria, TOPSIS Method, Multi Criteria Decision Making Techniques*

**JEL CLASSIFICATION:** *C13, C44, F15*

## 1. INTRODUCTION

With the accession of Croatia to the European Union (EU) accomplished in 2013, the number of member states reached to 28. The population of the EU is about 510.1 million people as of 1 January 2016. The most populous member state is Germany, with an estimated 82.1 (16%) million people, and the least populous member state is Malta with 0.4 (0.07%) million. The Gross Domestic Product (GDP) generated in European Union was worth 16229.46 billion US dollars in 2015. Germany has 20% share and Malta has 0.06% in the GDP. The GDP value of European Union represents 26.18 percent of the whole world economy.

This study measures the economic performance of 28 member states of the EU in 2011 and 2015 by a TOPSIS method, based on Multi Criteria Decision Making (MDCM) approach. Six macro-economic criteria are used to evaluate the performance of the countries. Four of these criteria are Maastricht convergence criteria which European Union member states are required to meet to enter the third stage of the Economic and Monetary Union (EMU) and adopt the euro as their currency.

TOPSIS is applied for different purposes. For instance, Agrawal et al. (1992) used TOPSIS for selection of grippers in flexible manufacturing. Agrawal et al. (1991) applied TOPSIS for robot selection. TOPSIS was also applied for financial investment in advanced manufacturing systems by Kim et al. (1997). In other manufacturing applications, Chau and Parkan (1995) used it in a case selecting a manufacturing process. Parkan and Wu (1999) used TOPSIS in an application selecting robotic processes. TOPSIS has also been used to compare company performances by Deng et al. (2000) and financial ratio performance within highway bus industry by Feng and Wang (2001). Karimi et al. (2010) applied TOPSIS to examine the

location decision for foreign direct investment in ASEAN countries. Dincer (2011) applied TOPSIS and WSA (Weighted Sum Approach) in analysis of economic activities of European Union Member States and candidate countries. Sieng and Yussof (2015) used a fuzzy TOPSIS method in comparing the performance of Malaysian human capital with other countries. Balcerzak and Pietrzak (2016) applied TOPSIS method to examine the progress achieved by European countries in the field of implementing the concept of sustainable development.

## 2. METHODOLOGY

There are a lot of multiple criteria techniques to help selection in conditions of multiple criteria. The acronym TOPSIS stands for technique for preference by similarity to the ideal solution. The pioneering TOPSIS study is carried out by Hwang and Yoon (1981). Later the technique is developed by Lai *et al.* (1994), and Yoon and Hwang (1995).
The concept behind this method is that the selected best alternative should have the shortest distance from the ideal solution and the farthest distance from the negative-ideal solution in the geometrical (Euclidean) sense. In other words, the ideal alternative has the best level of all attributes considered, whereas the negative ideal is the one with the worst attribute value. A TOPSIS solution is defined as the alternative that is simultaneous, farthest from the negative-ideal and closest to the ideal alternative. There are two main advantages in this method: its mathematical simplicity and high flexibility in the definition of the choice set. Chia and Liang (2009) listed three advantages of TOPSIS: simple, rationally comprehensible concept, good computational efficiency, and ability to measure the relative performance for each alternative in simple mathematical form.
The idea of TOPSIS can be expressed in a series of following steps:

**Step 1:** Creating a decision matrix

The alternates ($a_1$, $a_2$, $a_m$) which will be ranked are listed in the rows of the decision matrix and the evaluation criteria ($X_1$, $X_2$, $X_n$) which will be used for decision making are placed in the columns of matrix. Decision matrix can be tabulate as follows.

**Table 1: Decision Matrix**

| Alternatifler | Kriterler | | | |
|---|---|---|---|---|
| | $X_1$ | $X_2$ | … | $X_n$ |
| $a_1$ | $X_{11}$ | $X_{12}$ | … | $X_{1n}$ |
| $a_2$ | $X_{21}$ | $X_{22}$ | … | $X_{2n}$ |
| . | . | . | | . |
| . | . | . | | . |
| $a_m$ | $X_{m1}$ | $X_{m2}$ | … | $X_{mn}$ |

**Step 2:** Normalization of criterion values
Normalization aims at obtaining comparable scales. There are different ways of normalizing the criterion values. This paper uses vector normalization, which utilizes the ratio of the original value (*xij*) and the square-root of the sum of the original criterion values.
The advantage of this method is that all criteria are measured in dimensionless units, thus facilitating inter-criterion comparisons. This procedure is usually utilized in TOPSIS. The formula is:

$$r_{ij} = \frac{X_{ij}}{\sqrt{\sum_{i=1}^{m} X_{ij}^{2}}} \tag{1}$$

where *i* is the country, *j* is the *j*th evaluation indicator, **r***ij* is the indicator value after vector normalization for the *i*th county and *j*th evaluation indicator, **X***ij* is the original value of indicators for the *i*th country and *j*th evaluation indicator and, *m* is the number of countries.

**Step 3:** Weighted Normalization of Values

In this step, normalized values are multiplied by weight of each indicator. The formula is:

$$v_{ij} = w_{ij} \cdot r_{ir} \tag{2}$$

where $\boldsymbol{w}_j$ is the weight of *j*th evaluation indicator, **r***ij* is the indicator value after vector normalization for the *i*th county and *j*th evaluation indicator and $\mathbf{v}_{ij}$ is the indicator value after weighted normalization for the *i*th county and *j*th evaluation indicator.

**Step 4**: To determine ideal ($\mathbf{A}^{+}$) and worst ($\mathbf{A}^{-}$) solution

$$A^{+} = \left\{\left(\max_i v_{ij} \,\middle|\, j \in J\right), \left(\min_i v_{ij} \,\middle|\, j \in J'\right) \middle| i = 1,2,...,m\right\} = \left\{A_1^{+}, A_2^{+}, ..., A_j^{+}, ..., A_k^{+}\right\} \tag{3}$$

$$A^{-} = \left\{\left(\min_i v_{ij} \,\middle|\, j \in J\right), \left(\max_i v_{ij} \,\middle|\, j \in J'\right) \middle| i = 1,2,...,m\right\} = \left\{A_1^{-}, A_2^{-}, ..., A_j^{-}, ..., A_k^{-}\right\} \tag{4}$$

$J = \left\{j = 1,2,...k \middle| k \text{ belongs to benefit criteria}\right\}$, benefit criteria imply a larger indicator value and a higher performance score; $J' = \left\{j = 1,2,...k \middle| k \text{ belongs to cost criteria}\right\}$, cost criteria imply a smaller indicator value and a higher performance score.

**Step 5**: To calculate the separation measure

$$S_i^{+} = \sqrt{\sum_{j=1}^{k} \left(v_{ij} - A_j^{+}\right)^2} \text{ and } S_i^{-} = \sqrt{\sum_{j=1}^{k} \left(v_{ij} - A_j^{-}\right)^2} \tag{5}$$

The separation of each country from the ideal one $\left(S_i^{+}\right)$ and the worst one $\left(S_i^{-}\right)$ is then respectively given by:

$$C_i^{*} = \frac{S_i^{-}}{S_i^{+} + S_i^{-}} \quad 0 < C_i^{*} < 1 \tag{6}$$

**Step 6**: To calculate the relative closeness to the ideal solution ($C_i^{*}$).

**Step 7**: To rank the preference order according to the descending order of ($C_i^{*}$).

## 3. DATA

In this study, the 28 EU Countries will be evaluated and ranked according to their economic performance in 2015. The list of countries can be seen from Table 2.

**Table 2. The European Union Countries**

| Member Countries | Date of Membership | Member Countries | Date of Membership |
|---|---|---|---|
| Belgium | Founder | Czech Republic | 2004 |
| Germany | Founder | Estonia | 2004 |
| France | Founder | Cyprus | 2004 |
| Italy | Founder | Latvia | 2004 |
| Luxembourg | Founder | Lithuania | 2004 |
| Netherlands | Founder | Hungary | 2004 |
| Denmark | 1973 | Malta | 2004 |
| Ireland | 1973 | Poland | 2004 |
| UK | 1973 | Slovenia | 2004 |
| Greece | 1981 | Slovakia | 2004 |
| Spain | 1986 | Bulgaria | 2007 |
| Portugal | 1986 | Romania | 2007 |
| Austria | 1995 | Croatia | 2013 |
| Finland | 1995 | | |
| Sweden | 1995 | | |

To assess the performance of economies, six macro-economic indicators are used: long-term interest rates, general government deficit (-) and surplus (+) (as percentage of GDP), general government gross debt (as percentage of GDP), inflation rate, gross fixed capital formation (as percentage of GDP) and unemployment rate. The evaluation criteria and their orientation can be seen from Table 3.

**Table 3. Evaluation Criteria and Their Orientation**

| Code | Evaluation Criteria | Orientation |
|---|---|---|
| X1 | Long-term Interest Rates | Min |
| X2 | General government deficit (-) and surplus (+) (as percentage of GDP) | Max |
| X3 | General government gross debt (as percentage of GDP) | Min |
| X4 | Inflation Rates | Max |
| X5 | Gross Fixed Capital Formation (as percentage of GDP) | Max |
| X6 | Unemployment rate | Min |

In Table 3, the criteria coded by X2, X4 and X5 belong to benefit criteria in which the larger criterion value, the higher performance score. The criteria coded by X1, X3 and X6 belong to cost criteria in which the smaller criterion value, the higher performance score.
The first four of the criteria (X1, X2; X3 and X4) in Table 3 are among the Maastricht criteria. The Maastricht criteria are defined as convergence criteria in Article 121 of the Treaty establishing European Union under Title VII "Economic and Monetary Union", Chapter 4 "Transitional provisions".
To achieve the economic and monetary union, the Member States agrees on some convergence criteria: public balance, government debt, inflation and interest rates.
Actually, real GDP growth rate is another important criterion for measuring of economic performance of a country. We have not used that criterion in our study. Because the Irish

economy grew by 26.3% in 2015 according to revised numbers released by the island nation's Central Statistics Office (July 12).
The original GDP estimate showed Ireland growing at 7.8% in 2015. The updated numbers, seem to reflect the rash of corporate inversions over the last couple years, in which a number of companies merged with entities domiciled in Ireland in deals driven in part to take advantage of Ireland's rock-bottom 12.5% corporate tax rate (Phillips, 2016). Several US companies, including drugs maker Allergan, security systems provider Tyco and medical technology specialist Medtronic have domiciled in Ireland by buying a smaller Irish-registered rival and "inverting" into an Irish corporate structure.
A surge in aircraft imported into Ireland by leasing companies that send the jets out on loan to airlines was also among the main reasons for the economic growth. Lease operators based in Ireland account for about 20% of the global market, with sales of €7.8bn (Inman, 2016).
Annual growth rate of 26% while statistically accurate doesn't reflect reality of Irish economy in any meaningful way.
When we use that rate for Irish economy in our study, Ireland places on the top of the rank, which will not be true and affect the accuracy of our study. That's why we have not used real GDP growth rate as criterion. Instead, we have used gross fixed capital formation as percentage of GDP and unemployment rate.

The definition and orientation of all criteria are as follows:

**X1: Long-term Interest Rates (10-year government bond yields, secondary market. Annual average (%)):**
An interest rate is the cost or price of borrowing, or the gain from lending, normally expressed as an annual percentage amount. Ten-year government bond yields are often used as a measure for long-term interest rates.
Yields vary according to the price of the bond. Secondary market means that the bond price is not an issue price (primary market) but determined by supply and demand on the market.
High interest rates affect the investment negatively. The orientation of interest rates must be at minimum level. It means minimum rates are better than maximum rates.
According to interest rate convergence criterion, the nominal long-term interest rate must not exceed by more than 2 percentage points that of, at most, the three best-performing member states in terms of price stability (the same member states as those in the case of the price stability criterion).

**X2: General government deficit (-) and surplus (+) as percentage of GDP):**
Net borrowing (+)/net lending (-) of general government is the difference between the revenue and the expenditure of the general government sector. The general government sector comprises the following sub-sectors: central government, state government, local government, and social security funds.
GDP used as a denominator is the gross domestic product at current market prices.
The negative values related to public balance mean government deficit, positive values mean government surplus.
The orientation of public balance variable must be at maximum level. It means positive values are better than negative values.
According to Maastricht criteria, the ratio of the annual government deficit to gross domestic product (GDP) cannot exceed 3% at the end of the preceding financial year.

**X3: General government gross debt as percentage of GDP):**
The general government sector comprises the sub-sectors of central government, state government, local government and social security funds. GDP used as a denominator is the gross domestic product at current market prices.
Debt is valued at nominal (face) value, and foreign currency debt is converted into national currency using end-year market exchange rates (though special rules apply to contracts).
The national data for the general government sector are consolidated between the sub-sectors. Basic data are expressed in national currency, converted into euro using end-year exchange rates for the euro provided by the European Central Bank. The orientation of government debt variable must be at minimum level. According to Maastricht criteria, the ratio of gross government debt to GDP should not exceed 60% at the end of the preceding financial year.

**X4: Inflation Rates (Annual average rate of change in Harmonized Indices of Consumer Prices (HICPs)):** Harmonized Indices of Consumer Prices (HICPs) are designed for international comparisons of consumer price inflation. HICP is used for example by the European Central Bank for monitoring of inflation in the Economic and Monetary Union and for the assessment of inflation convergence. Generally, the orientation of inflation rate must be at minimum level. It means minimum rates are better than maximum rates. This situation is valid when inflation rates of all the countries are positive. But in 2015, almost half of the countries had deflation. It means that the deflation values were negative. The other half had very low positive (0%-1.2%) inflation rates. If we accept that minimum rates are better than maximum rates, it means that deflation is better than inflation, which is not true. Low inflation rates will stimulate production of firms while deflation discourage firms from production. That's why, in this study we accept that maximum inflation rates which are positive and very low in 2015 are better than the deflation rates which are negative in 2015.
According to Maastricht inflation convergence criterion, the inflation rate of a state should not exceed by more than 1.5 percentage points that of the three best-performing member states.

**X5: Gross fixed capital formation as percentage of GDP:**
Gross fixed capital formation (GFCF) consists of resident producers' acquisitions, less disposals, of fixed assets during a given period plus certain additions to the value of non-produced assets realized by the productive activity of producer or institutional units. GFCF includes acquisition less disposals of, e.g. buildings, structures, machinery and equipment, mineral exploration, computer software, literary or artistic originals and major improvements to land such as the clearance of forests.
GFCF is the main source of national production and employment in a country. If the share of GFCF in GDP increases, it will generate more output and create new employment opportunities. Higher GFCF rates reflect higher performance. So, the orientation of GFCF rate must be at maximum level.

**X6: Unemployment rate** (as percentage):
Unemployment rates represent unemployed persons as percentage of the labor force. The labor force is the total number of people employed and unemployed.
Unemployed persons comprise persons aged 15 to 74 who were: a. without work during the reference week, b. currently available for work, i.e. were available for paid employment or self-employment before the end of the two weeks following the reference week, c. actively seeking work, i.e. had taken specific steps in the four weeks' period ending with the reference week to

seek paid employment or self-employment or who found a job to start later, i.e. within a period of, at most, three months.
Minimum unemployment rate implies maximum employment rate. So, the orientation of unemployment rate must be at minimum level.
The data are collected from Eurostat homepage http://ec.europa.eu/eurostat/en/data/browse-statistics-by-theme excluding Estonia's long term interest rate in 2015, which is collected from OECD Economic Outlook No 95 - Long-term Baseline Projections, 2014 http://knoema.com/OECDEOLTBP2014/economic-outlook-no-95-long-term-baseline-projections-2014.

## 4. THE APPLICATON AND EMPIRICAL RESULTS

The evaluation criteria and the list of countries were given in section 3. There are six evaluation criteria and 28 countries. The base year is 2015. These countries will be ranked according to six criteria by TOPSIS method, the steps of which were explained in section 2. Microsoft Excel 2016 has been used for the calculations.

**Step 1:** Creating a decision matrix
The countries which will be ranked has been listed in the rows of the matrix and the evaluation criteria which will be used for decision making are placed in the columns of matrix. There are 28 countries and 6 evaluation criteria whose definition and orientation are given in previous section. For TOPSIS method a standard decision matrix (28x6) has been created. The decision matrix of the criteria for the year of 2015 can be seen from Table 4.

**Table 4. The Decision Matrix of the Criteria (2015)**

| **Countries** | **Criteria (% Values)** | | | | | |
|---|---|---|---|---|---|---|
| | Long Term Interest Rates | Budget Balance (%GDP) | Government Debt (%GDP) | Inflation Rate | Gross Fixed Capital Formation (%GDP) | Unemployment Rate |
| **Belgium** | 0,84 | -2,6 | 106 | 0,6 | 23,34 | 8,5 |
| **Bulgaria** | 2,49 | -2,1 | 26,7 | -1,1 | 21,18 | 9,2 |
| **Czech Republic** | 0,58 | -0,4 | 41,1 | 0,3 | 26,31 | 5,1 |
| **Denmark** | 0,69 | -2,1 | 40,2 | 0,2 | 19,03 | 6,2 |
| **Germany** | 0,5 | 0,7 | 71,2 | 0,1 | 19,99 | 4,6 |
| **Estonia** | 0,074 | 0,4 | 9,7 | 0,1 | 24,23 | 6,2 |
| **Ireland** | 1,18 | -2,3 | 93,8 | 0 | 21,20 | 9,4 |
| **Greece** | 9,67 | -7,2 | 176,9 | -1,1 | 11,66 | 24,9 |
| **Spain** | 1,73 | -5,1 | 99,2 | -0,6 | 20,37 | 22,1 |
| **France** | 0,84 | -3,5 | 95,8 | 0,1 | 21,51 | 10,4 |
| **Croatia** | 3,55 | -3,2 | 86,7 | -0,3 | 19,12 | 16,3 |
| **Italy** | 1,71 | -2,6 | 132,7 | 0,1 | 16,52 | 11,9 |
| **Cyprus** | 4,54 | -1 | 108,9 | -1,5 | 13,37 | 15 |
| **Latvia** | 0,96 | -1,3 | 36,4 | 0,2 | 22,81 | 9,9 |
| **Lithuania** | 1,38 | -0,2 | 42,7 | -0,7 | 20,76 | 9,1 |
| **Luxembourg** | 0,37 | 1,2 | 21,4 | 0,1 | 17,37 | 6,4 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Hungary** | 3,43 | -2 | 75,3 | 0,1 | 21,33 | 6,8 |
| **Malta** | 1,49 | -1,5 | 63,9 | 1,2 | 24,93 | 5,4 |
| **Netherlands** | 0,69 | -1,8 | 65,1 | 0,2 | 19,43 | 6,9 |
| **Austria** | 0,75 | -1,2 | 86,2 | 0,8 | 22,61 | 5,7 |
| **Poland** | 2,7 | -2,6 | 51,3 | -0,7 | 20,14 | 7,5 |
| **Portugal** | 2,42 | -4,4 | 129 | 0,5 | 15,04 | 12,6 |
| **Romania** | 3,47 | -0,7 | 38,4 | -0,4 | 24,72 | 6,8 |
| **Slovenia** | 1,71 | -2,9 | 83,2 | -0,8 | 19,38 | 9 |
| **Slovakia** | 0,89 | -3 | 52,9 | -0,3 | 23,02 | 11,5 |
| **Finland** | 0,72 | -2,7 | 63,1 | -0,2 | 20,42 | 9,4 |
| **Sweden** | 0,72 | 0 | 43,4 | 0,7 | 24,21 | 7,4 |
| **United Kingdom** | 1,78 | -4,4 | 89,2 | 0 | 16,95 | 5,3 |

**Step 2:** Normalization of criterion values

In the Step 2, using the values of decision matrix in Tablo 4, normalized criterion matrix and criterion weights for the year 2015 in Table 5 have been created.

The weights of all criteria have been the same, which is 0,166667 percent each. The sum of weights should be 1. We have 6 criteria. When you attribute equal weight to each criterion, you simply divide 1 to 6. The results is 0,166667.

**Table 5. Normalized Criterion Matrix and Criterion Weights (2015)**

| **Countries** | **Criteria** | | | | | |
|---|---|---|---|---|---|---|
| | Long Term Interest Rates (Min) | Budget Balance (%GDP) (Max) | Government Debt (%GDP) (Min) | Inflation Rate (Max) | Gross Fixed Capital Formation (%GDP) | Unemployment Rate (Min) |
| **Belgium** | 0,060339 | -0,1775 | 0,245893 | 0,185341 | 0,213346594 | 0,149303 |
| **Bulgaria** | 0,178861 | -0,14337 | 0,061937 | -0,33979 | 0,193612826 | 0,161598 |
| **Czech Republic** | 0,041662 | -0,02731 | 0,095342 | 0,09267 | 0,24043011 | 0,089582 |
| **Denmark** | 0,049564 | -0,14337 | 0,093254 | 0,06178 | 0,173976941 | 0,108903 |
| **Germany** | 0,035916 | 0,04779 | 0,165166 | 0,03089 | 0,182671208 | 0,080799 |
| **Estonia** | 0,005316 | 0,027308 | 0,022502 | 0,03089 | 0,221427768 | 0,108903 |
| **Ireland** | 0,084761 | -0,15702 | 0,217592 | 0 | 0,193775272 | 0,165111 |
| **Greece** | 0,694611 | -0,49155 | 0,410363 | -0,33979 | 0,106546308 | 0,437369 |
| **Spain** | 0,124269 | -0,34818 | 0,230119 | -0,18534 | 0,186165596 | 0,388187 |
| **France** | 0,060339 | -0,23895 | 0,222232 | 0,03089 | 0,196612142 | 0,182676 |
| **Croatia** | 0,255002 | -0,21847 | 0,201122 | -0,09267 | 0,17471521 | 0,28631 |
| **Italy** | 0,122832 | -0,1775 | 0,307831 | 0,03089 | 0,150986702 | 0,209024 |
| **Cyprus** | 0,326115 | -0,06827 | 0,252621 | -0,46335 | 0,122200135 | 0,263476 |
| **Latvia** | 0,068958 | -0,08875 | 0,084439 | 0,06178 | 0,208470373 | 0,173894 |
| **Lithuania** | 0,099128 | -0,01365 | 0,099053 | -0,21623 | 0,189718058 | 0,159842 |
| **Luxembourg** | 0,026578 | 0,081925 | 0,049643 | 0,03089 | 0,158757738 | 0,112416 |
| **Hungary** | 0,246382 | -0,13654 | 0,174677 | 0,03089 | 0,194998204 | 0,119442 |
| **Malta** | 0,107029 | -0,10241 | 0,148232 | 0,370681 | 0,227895629 | 0,094851 |
| **Netherlands** | 0,049564 | -0,12289 | 0,151016 | 0,06178 | 0,177564756 | 0,121199 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Austria** | 0,053874 | -0,08193 | 0,199962 | 0,247121 | 0,206639524 | 0,100121 |
| **Poland** | 0,193945 | -0,1775 | 0,119003 | -0,21623 | 0,184052845 | 0,131738 |
| **Portugal** | 0,173832 | -0,30039 | 0,299248 | 0,154451 | 0,137448866 | 0,221319 |
| **Romania** | 0,249256 | -0,04779 | 0,089078 | -0,12356 | 0,225896512 | 0,119442 |
| **Slovenia** | 0,122832 | -0,19799 | 0,193003 | -0,24712 | 0,177119821 | 0,158085 |
| **Slovakia** | 0,06393 | -0,20481 | 0,122715 | -0,09267 | 0,210364411 | 0,201998 |
| **Finland** | 0,051719 | -0,18433 | 0,146376 | -0,06178 | 0,186681713 | 0,165111 |
| **Sweden** | 0,051719 | 0 | 0,100677 | 0,216231 | 0,221239244 | 0,129981 |
| **United Kingdom** | 0,12786 | -0,30039 | 0,206922 | 0 | 0,154881894 | 0,093095 |
| **Weights** | 0,166667 | 0,166667 | 0,166667 | 0,166667 | 0,166667 | 0,166667 |

**Step 3:** Weighted Normalization of Values and **Step 4**: To determine ideal ($\mathbf{A}^+$) and worst ($\mathbf{A}^-$) solution

In this step, normalized values are multiplied by weight of each indicator. Next, the weighted criterion matrix is formed as shown in Table 6 for the year 2015. Ideal and worst values obtained after weighted criterion matrix is formed and are shown at the bottom of Table 6.

**Table 6. Weighted Criterion Matrix (2015)**

| **Countries** | **Criteria** | | | | | |
|---|---|---|---|---|---|---|
| | Long Term Interest Rates (Min) | Budget Balance (%GDP) (Max) | Government Debt (%GDP) (Min) | Inflation Rate (Max) | Gross Fixed Capital Formation (%GDP) | Unemployment Rate (Min) |
| **Belgium** | 0,010056 | -0,02958 | 0,040982 | 0,03089 | 0,035558 | 0,024883804 |
| **Bulgaria** | 0,02981 | -0,02389 | 0,010323 | -0,05663 | 0,032269 | 0,026933058 |
| **Czech Republic** | 0,006944 | -0,00455 | 0,01589 | 0,015445 | 0,040072 | 0,014930282 |
| **Denmark** | 0,008261 | -0,02389 | 0,015542 | 0,010297 | 0,028996 | 0,018150539 |
| **Germany** | 0,005986 | 0,007965 | 0,027528 | 0,005148 | 0,030445 | 0,013466529 |
| **Estonia** | 0,000886 | 0,004551 | 0,00375 | 0,005148 | 0,036905 | 0,018150539 |
| **Ireland** | 0,014127 | -0,02617 | 0,036265 | 0 | 0,032296 | 0,02751856 |
| **Greece** | 0,115769 | -0,08193 | 0,068394 | -0,05663 | 0,017758 | 0,072894908 |
| **Spain** | 0,020711 | -0,05803 | 0,038353 | -0,03089 | 0,031028 | 0,06469789 |
| **France** | 0,010056 | -0,03982 | 0,037039 | 0,005148 | 0,032769 | 0,030446066 |
| **Croatia** | 0,0425 | -0,03641 | 0,03352 | -0,01545 | 0,029119 | 0,047718353 |
| **Italy** | 0,020472 | -0,02958 | 0,051305 | 0,005148 | 0,025164 | 0,034837325 |
| **Cyprus** | 0,054353 | -0,01138 | 0,042103 | -0,07723 | 0,020367 | 0,043912595 |
| **Latvia** | 0,011493 | -0,01479 | 0,014073 | 0,010297 | 0,034745 | 0,028982313 |
| **Lithuania** | 0,016521 | -0,00228 | 0,016509 | -0,03604 | 0,03162 | 0,026640308 |
| **Luxembourg** | 0,00443 | 0,013654 | 0,008274 | 0,005148 | 0,02646 | 0,018736041 |
| **Hungary** | 0,041064 | -0,02276 | 0,029113 | 0,005148 | 0,0325 | 0,019907043 |
| **Malta** | 0,017838 | -0,01707 | 0,024705 | 0,06178 | 0,037983 | 0,015808534 |
| **Netherlands** | 0,008261 | -0,02048 | 0,025169 | 0,010297 | 0,029594 | 0,020199794 |
| **Austria** | 0,008979 | -0,01365 | 0,033327 | 0,041187 | 0,03444 | 0,016686786 |
| **Poland** | 0,032324 | -0,02958 | 0,019834 | -0,03604 | 0,030675 | 0,021956298 |
| **Portugal** | 0,028972 | -0,05007 | 0,049875 | 0,025742 | 0,022908 | 0,03688658 |
| **Romania** | 0,041543 | -0,00796 | 0,014846 | -0,02059 | 0,037649 | 0,019907043 |
| **Slovenia** | 0,020472 | -0,033 | 0,032167 | -0,04119 | 0,02952 | 0,026347557 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Slovakia** | 0,010655 | -0,03414 | 0,020452 | -0,01545 | 0,035061 | 0,033666323 |
| **Finland** | 0,00862 | -0,03072 | 0,024396 | -0,0103 | 0,031114 | 0,02751856 |
| **Sweden** | 0,00862 | 0 | 0,01678 | 0,036038 | 0,036873 | 0,021663547 |
| **United Kingdom** | 0,02131 | -0,05007 | 0,034487 | 0 | 0,025814 | 0,015515784 |
| **Ideal ($A^+$)** | 0,000886 | 0,013654 | 0,00375 | 0,06178 | 0,040072 | 0,013466529 |
| **Worst ($A^-$)** | 0,115769 | -0,08193 | 0,068394 | -0,07723 | 0,017758 | 0,072894908 |

As it can be seen from the table, according to the long term interest rates criterion whose orientation is min which means minimum values imply higher performance, Estonia represents the ideal solution ($A^+$) and Greece represents the worst solution ($A^-$). In other words, Estonia has the best performance with (0,000886) and Greece has the worst performance with (0,115769). In regard to budget balance as percentage of GDP criterion whose orientation is max which larger criterion value means higher performance, Luxembourg has the highest performance with (0.013654) and Greece has the lowest performance with (-0.08193). As regards government debt as percentage of GDP criterion whose orientation is min, Estonia has once again highest performance with (0,00375) and Greece is the worst performance with (0,068394). Malta has the best performance with (0,06178) and Cyprus has the worst performance with (-0,07723) considering inflation rate criterion whose orientation is max.
For gross fixed capital formation as percentage of GDP criterion whose orientation is max, Czech Republic has the best performance with (0,040072) and Greece has the worst performance with (0,017758). In terms of unemployment criterion whose orientation is min, Germany has the highest performance with (0,013466529) and Greece has the lowest performance with (0,072894908).
**Step 5**: To calculate the separation measure ($S^+$, $S^-$), **Step 6**: To calculate the relative closeness to the ideal solution ($C_i^*$) and **Step 7**: To rank the preference order according to the descending order of ($C_i^*$) for 2015 will be shown all together in Table 7.

**Table 7. Final Ranking of Countries (2015)**

| **No** | **Countries** | **2015** | | |
|---|---|---|---|---|
| | | $S^+$ | $S^-$ | $C^*$ |
| 1 | Sweden | 0,034001 | 0,191508 | 0,849225 |
| 2 | Malta | 0,04099 | 0,196713 | 0,827558 |
| 3 | Austria | 0,046392 | 0,186423 | 0,800735 |
| 4 | Czech Republic | 0,05162 | 0,181746 | 0,778803 |
| 5 | Estonia | 0,057637 | 0,187093 | 0,764489 |
| 6 | Luxembourg | 0,058764 | 0,186924 | 0,760817 |
| 7 | Germany | 0,062638 | 0,179668 | 0,741491 |
| 8 | Latvia | 0,062833 | 0,167952 | 0,727744 |
| 9 | Belgium | 0,066669 | 0,170226 | 0,718571 |
| 10 | Denmark | 0,066321 | 0,168826 | 0,717958 |
| 11 | Netherlands | 0,066963 | 0,166669 | 0,713383 |
| 12 | Ireland | 0,083026 | 0,150685 | 0,64475 |
| 13 | France | 0,087184 | 0,150809 | 0,63367 |
| 14 | Hungary | 0,083002 | 0,142952 | 0,63266 |
| 15 | Finland | 0,08904 | 0,150848 | 0,628828 |

| | | | | |
|---|---|---|---|---|
| 16 | Italy | 0,091655 | 0,142835 | 0,609128 |
| 17 | Slovakia | 0,095158 | 0,145898 | 0,605244 |
| 18 | Portugal | 0,09549 | 0,144281 | 0,601745 |
| 19 | Romania | 0,095269 | 0,142329 | 0,599032 |
| 20 | Lithuania | 0,102345 | 0,151374 | 0,596621 |
| 21 | United Kingdom | 0,097192 | 0,142857 | 0,595115 |
| 22 | Poland | 0,113338 | 0,128525 | 0,531396 |
| 23 | Slovenia | 0,119361 | 0,128029 | 0,51752 |
| 24 | Croatia | 0,111272 | 0,115046 | 0,508339 |
| 25 | Bulgaria | 0,12866 | 0,129907 | 0,502411 |
| 26 | Spain | 0,134251 | 0,113576 | 0,458287 |
| 28 | Cyprus | 0,159981 | 0,101423 | 0,387994 |
| 28 | Greece | 0,2111 | 0,020593 | 0,088882 |

In TOPSIS method which is one of MCDM methods countries are evaluated not according to single criterion but according to multi criteria with their weights which are accepted as equal (1/6) in our study. Table 7 shows the ranking of the overall performance of countries which is calculated according to relative closeness to the ideal solution ($C^*$).

According to Table 7, Sweden is the closest country to the ideal solution, which means it has the highest performance with 0,849225 $C^*$ value. And Greece which experiences a deep economic crisis for a while has the worst performance.

Together with Sweden, Malta, Austria, Czech Republic and Estonia share the first five ranks respectively and Croatia, Bulgaria, Spain, Cyprus and Greece share the last five ranks respectively. The Table 7 also shows that some small countries which accessed to the EU in 2004 such as Malta, Czech Republic and Estonia have higher performance than the big and old members of the EU such as France, United Kingdom, Italy, France and Germany.

## 5. CONCLUSIONS

In this study, economic performance of the EU countries is measured. Six economic performance criteria for 28 countries in 2015 are evaluated and countries are ranked by using TOPSIS method. According to the analysis result, Sweden has the best economic performance among the 28 EU countries. Greece has the worst economic performance.

Together with Greece Croatia, Bulgaria, Spain and Cyprus are the weakest chains of the EU. These countries may have economic problems in the years ahead if they do not take strict economic measures as soon as possible.

The study also shows that some small countries which accessed to the EU in 2004 such as Malta, Czech Republic and Estonia have higher performance than the big and old members of the EU such as France, United Kingdom, Italy, France and Germany.

In small countries taking, implementing and seeing the results of economic measures is relatively easier the big countries.

It is beyond doubt that when we increase, decrease the number of economic criteria or change them, the results will change. It is also possible that if the weights of criteria are changed, the results may change.

In our paper each of the six criteria has 1/6 weight. Further researches can be made by elimination of these limitations. It is also possible to use other MCDM methods such as ELECTRE, AHP, PROMETHEE, VIKOR etc.

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## REFERENCES

Agrawal, V.P., A. Verma and Agarwal, S. (1992). Computer-aided evaluation and selection of optimum grippers. *International Journal of Production Research*, 30 (11), 2713–2732.

Agrawal, V.P., V. Kohli and Gupta, S. (1991). Computer aided robot selection: The multiple attribute decision making approach. *International Journal of Production Research*, 29 (8), 1629–1644.

Balcerzak, A. P. and Pietrzak, M. B. (2016). Application of TOPSIS Method for Analysis of Sustainable Development in European Union Countries, *Institute of Economic Research Working Papers*, No:22/2016

Chau, O.L. and Parkan, C. (1995). Selection of a manufacturing process with multiple attributes: A case study. *Journal of Engineering Technology Management*, 12, 219–237.

Chia C.H. and Liang H. C. (2009). A fuzzy TOPSIS decision making model with entropy weight under intuitionistic fuzzy environment. *Proceedings of the International Multi Conference of Engineers and Computer Scientists.* Vol. 1.

Deng, H., C.H. Yeh and Willis, R.J. (2000). Inter-company comparison using modified TOPSIS with objective weights. *Computers & Operations Research*, 27 (10), 963–974,

Dincer, S.E. (2011). Multi-criteria analysis of economic activity for European Union Member States and candidate countries: TOPSIS and WSA applications. *European Journal of Social Sciences* 21(4), 563-572.

Feng, C.M. and Wang, R.T. (2001). Considering the financial ratios on the performance evaluation of highway bus industry. *Transport Reviews*, 21 (4), 449–467.

Hwang, C.L. and Yoon, K. (1981). *Multiple Attribute Decision Making: Methods and Applications*. Springer-Verlag, New York.

Inman, P. (2016, July 12). Irish Economy Surges 26% as Revised Figures Take in Foreign Investment. *The Guardian News*. Retrieved August 15, 2016, from https://www.theguardian.com/business/2016/jul/12/irish-economic-growth-revised-figures-foreign-investment-aircraft

Karimi M. S, Yusop Z., & Law S. H. (2010). Location decision for foreign direct investment in ASEAN countries: A TOPSIS approach. *International Research Journal of Finance and Economics* 36 (1), 196-207.

Kim, G., C. Park and Yoon, K.P. (1997). Identifying investment opportunities for advanced manufacturing system with comparative-integrated performance measurement. *International Journal of Production Economics*, 50, 23–33.

Lai, Y.-J., T.-Y. Liu and Hwang, C.-L. (1994). TOPSIS for MODM. *European Journal of Operational Research*, 76 (3), 486–500.

Parkan, C. and Wu, M.L. (1999). Decision-making and performance measurement models with applications to robot selection. *Computers & Industrial Engineering*, 36 (3), 503–523,

Phillips, M. (2016, July 13). *Ireland's 26% growth is more paper tiger than Celtic tiger*. Retrieved August 15, 2016, from http://qz.com/730030/irelands-26-growth-is-more-paper-tiger-than-celtic-tiger/

Sieng, L., W. and Yussof, I. (2015). Comparative study of Malaysia human capital with selected ASEAN and developed countries: a fuzzy TOPSIS method. *Geography: Malaysian Journal of Society and Space*, 11 (6), 11-22.

Yoon, K. and Hwang, C.L. (1995). *Multiple Attribute Decision Making: An Introduction*, Sage, Thousand Oaks, CA.