7th International Scientific Conference
"Business and Management 2012"
May 10-11, 2012, Vilnius, LITHUANIA

ISSN 2029-4441 print / ISSN 2029-929X online
ISBN 978-609-457-116-9 CD
doi:10.3846/bm.2012.043
http://www.bm.vgtu.lt

ECONOMIC RANKING OF THE EUROPEAN UNION COUNTRIES BY MULTIMOORA OPTIMIZATION

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Abstract. The aim of this paper is to apply the multi-objective optimization method MULTIMOORA in sovereign rating analysis and thus rank the European Union (EU) Member States. The following tasks are thus set: 1) to describe the MULTIMOORA method; 2) to establish an indicator system for credit rating; and 3) to rank the EU Member States and discuss the future challenges. Rating agencies like Moody's rate countries economic growth drivers by internal analysts using unclear methods, probably mostly on a qualitative basis, with a final judgment by the board of directors acting as decision makers and being judge of one's own case. These ratings influence the countries credit rating and ipso facto of their firms. MULTIMOORA, a quantitative method comparing multiple objectives expressed in different units, unless similar methods, does not need normalization being based on dimensionless measures. The analysis was based on objectives originating both from statistics and from forecasts and characterizing the 27 EU Member States' economies. A Dominance Theory, summarizing the three obtained ordinal numbers per country ranks the 27 countries. As a result, Sweden, Luxembourg, and Finland were the top-ranked states, whereas so called PIIGS sates remained at the very bottom.

Keywords: multi-objective optimization, European Union, credit rating, MULTIMOORA.

Jel classification: C44, E61, F59, M2, O22

1. Introduction

Due to the recent economic recession as well as financial collapses of Iceland, Hungary, Greece, and Ireland more attention was paid on the sovereign credit ratings offered by the major rating agencies, namely Moody's, Fitch Ratings, and Standard & Poor's (S&P). Indeed, the higher values of credit ratings suggest certain state being less likely to default and therefore impact many business as well as government decisions to a certain degree. Indeed, as Afonso *et al.* (2011) put it, these sovereign credit ratings have three-fold impact. Firstly, sovereign ratings influence the interest rates a country faces in the international financial market and, therefore, its borrowing costs. More specifically, Ismailescu and Kazemi (2010) report the linkage between credit default swap spreads and sovereign rating. Secondly, sovereign ratings may have a constraining impact on the ratings assigned to domestic banks or companies. Thirdly, some institutional investors have lower bounds for the risk that they can assume in their investments. The described pattern suggests that risk ratings affect not only investment decisions in the international markets of certain financial instruments (i. e. bonds, loans, and foreign exchange operations) but also allocation of foreign direct investment and portfolio equity flows (Reinhart, Rogoff 2004; Ratha *et al.* 2011). As for the developing countries, the allocation of performance-based official aid is also increasingly being linked to sovereign rating.

The three main rating offices: Standard & Poor's, Moody's and Fitch were founded in the period 1909-1924. It was the time of large infrastructure works in the United States and large companies asked financing by bonds. The rating offices rated the solvability of the borrower. Since then three important changes took place.

First, not only corporate bonds were considered but also government bonds. Ipso facto the country involved was considered too.

Second, in the early 1970s the model changed. An "Issuer Pays Model", whereby the entity issuing the bonds also pays the rating firm, replaced "The Investor Pays" model. This change opened the door to conflicts of interest as the client was the victim at the same time.

Third one could say that the rating agencies are no more entirely independent. Standard & Poor's belongs to McGraw-Hill, a publishing house. Fitch is mainly in the hands of the French holding Fimalec. Moody's is independent but 13% of the shares are in hands of Warren Buffet, one of the richest persons in the world and head of a famous investment fund. In the European Union a tendency exists to organize a control on the rating offices given their said bad influence on the recent recession periods.

Rating agencies like Moody's, rate countries economic growth drivers by internal experts using unclear methods, probably mostly on a qualitative basis but with final judgment by the management acting as decision makers. These ratings influence the credit rating of the bonds of private companies but also of the government bonds and finally of the countries themselves. The information on the rating offices comes mainly from: Money Expert Deutsche Bank (2011), White (2010), and Afonso *et al.* (2011).

Multi-objective optimaztion (MOO) methods are the proper tool to handle the complex problems of socio-economic assessments (Kaplinski, Peldschus 2011; Zavadskas, Turskis 2011). It is due to Løken (2007) that Belton and Stewart (2004) defined the three broad categories of MCDM methods: 1) value measurement models; 2) goal, aspiration, and reference level models; 3) outranking models (the French school). In this study we will apply the MULTIMOORA method (Brauers, Zavadskas 2010) encompassing the first two options.

The aim of this study is to ask if more quantitative approaches based on statistics and forecasts are not preferable for countries level of economic activity. Such a method has to compare multiple objectives characterizing the economies of each country. To be specific, the MULTIMOORA method will be applied for sovereign rating analysis. The following tasks are thus set: 1) to describe the MULTIMOORA method; 2) to establish an indicator system for credit rating; and 3) to rank the EU Member States and discuss the future challenges.

Table 1. Objectives characterizing the Economies of the European Union Member States

No	Indicator	Period	Dimension	Optimum
A. Actual				
1	Government Budget Deficit (a)	2010	% of GDP	MIN
2	Government Debt (a)	2010	% of GDP	MIN
3	Current account deficit (BoP) (a)	2010	% of GDP	MIN
4	GDP per capita in PPP (a)	2010	in current international dollar	MAX
5	GDP growth rate (a)	2010	%of GDP of previous year	MAX
6	Inflation (a)	2010	per cent	MIN
7	Government bond yields (a)	2010	%	MIN
8	Employment rate (b)	2010	%of age group 15-64	MAX
9	Unemployment rate (b)	2010	%of age group 15-64	MIN
10	Tertiary education (b)	2010	%of age group 30-34	MAX
B. Prospective				
11	Median Age (b)	2010	Median of total population	MIN
12	Proportion of population aged 0-14 (b)	2010	%of total population	MAX
13	Proportion of population aged 15-64 (b)	2010	%of total population	MAX
14	Proportion of population aged >65 (b)	2010	%of total population	MIN
15	GDP per capita (EU-15=100) (c)	2011	index, EU-15=100	MAX
16	GDP growth rate (c)	2011	% of GDP of previous year	MAX
17	Government Budget Deficit (c)	2011	% of GDP	MIN
18	Government consolidated gross debt (c)	2011	% of GDP	MIN
19	GDP per capita (EU-15=100) (c)	2012	index, EU-15=100	MAX
20	GDP growth rate (c)	2012	%of GDP of previous year	MAX
21	Government Budget Deficit (c)	2012	% of GDP	MIN
22	Government consolidated gross debt (c)	2012	% of GDP	MIN

The data come from (a) IMF and World Bank (2011), (b) EUROSTAT (2011), and (c) European Commission (2011).

2. Choice of objectives characterizing the economies of the EU countries in the present and in the future

The national economies to be studied concern the Economies of the European Union Member States. We selected twenty-two objectives, ten originating from statistics and twelve from statistics and forecasts important for the future, in order to characterize the 27 EU countries economies as shown in the following Table 1.

As one can note, the proposed indicator system (Table 1) covers actual (group A) and prospective (group B) values of socio–economic indicators. Therefore we are to evaluate not only current situation and short–term prospective, but also medium- and long-term ones. In addition, the indicators under consideration are expressed in different dimensions and therefore needs to be tackled with multi-objective optimization method. The following Section 3 describes the MULTIMOORA method applied for the rating.

3. Preliminaries for MULTIMOORA

This section describes MOO procedure according to MULTIMOORA. The first sub-section discusses the very MULTIMOORA method and different parts thereof, whereas the second sub-section presents the Dominance theory (Baruers, Zavadskas 2011). The latter theory is applied to summarize ranks provided by different parts of MULTIMOORA and thus obtain a robust ranking.

Up to now MULTIMOORA has been applied in The MULTIMOORA was applied as well as in a manufacturing and engineering environment (Kracka *et al.* 2010; Chakraborty 2011; Kalibatas and Turskis 2008), as in regional development studies (Brauers and Ginevičius 2009, 2010).

3.1. The MULTIMOORA method

In this study we will apply the MULTIMOORA method which encompasses value measurement as well as reference level methods. Brauers (2004) described the three parts of MULTIMOORA, namely the Ratio System Approach, the Reference Point Approach (but still based on scores), and the Full Multiplicative Form. In this way dimensionless measures were obtained. Later on this combination was called MOORA by Brauers and Zavadskas (2006). Finally Brauers and Zavadskas (2010) launched MULTIMOORA. MULTIMOORA is composed of MOORA and of the Full Multiplicative Form of Multiple Objectives. MOORA method begins with matrix X where its elements x_{ij} denote *i*-th alternative of *j*-th objective ($i = 1, 2, \cdots, m$ and $j = 1, 2, \cdots, n$). MOORA method consists of two parts: the ratio system and the reference point approach.

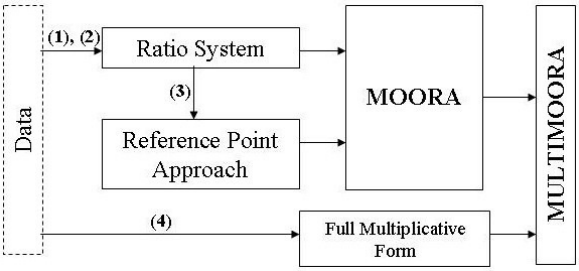

Fig.1. The procedure of multi-criteria evaluation according to the MULTIMOORA method, numbers of respective formulas given in parentheses (Source: Baležentis *et al.* 2010)

The Ratio System of MOORA. Ratio system defines data normalization by comparing alternative of an objective to all values of the objective:

$$x_{ij}^{*} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^{2}}}, \qquad (1)$$

where x_{ij}^{*} denotes *i*-th alternative of *j*-th objective (in this case – *j*-th structural indicator of *i*-th state). Usually these numbers belong to the interval [-1; 1]. These x_{ij}^{*} are added (if desirable value of indicator is maximum) or subtracted (if desirable value is minimum) delivering a sum for each alternative in this way:

$$y_{i}^{*} = \sum_{j=1}^{g} x_{ij}^{*} - \sum_{j=g+1}^{n} x_{ij}^{*}, \qquad (2)$$

where $g = 1, \cdots, n$ denotes number of objectives to be maximized. Then every outcome per alternative is ranked in a descending order.

The Reference Point of MOORA. Reference point approach is based on the ratios obtained in the Ratio System. The Maximal Objective Reference Point (vector) is found according to ratios found in Eq. 1. The *j*-th coordinate of the reference point can be described as $r_j = \max_i x_{ij}^{*}$ in case of maximization. Every coordinate of this vector represents maximum or minimum of certain objective. Then every element of normalized responses matrix is recalculated and the ranks are given according to deviations from the reference point and after the Min-Max Metric of Tchebycheff:

$$\min_i \left(\max_j \left| r_j - x_{ij}^* \right| \right). \quad (3)$$

Finally, the outcomes per alternative are ranked in an ascending order.

The Full Multiplicative Form and MULTIMOORA. The Full Multiplicative Form method embodies maximization as well as minimization of purely multiplicative utility function. Overall utility of the *i*-th alternative can be expressed as a dimensionless number:

$$U_i' = \frac{A_i}{B_i}, \quad (4)$$

where $A_i = \prod_{j=1}^{g} x_{ij}$, $i = 1, 2, \cdots, m$ denotes the product of objectives of the *i*-th alternative to be maximized with $g = 1, \cdots, n$ being the number of objectives (structural indicators) to be maximized and

where $B_i = \prod_{j=g+1}^{n} x_{ij}$ denotes the product of objectives of the *i*-th alternative to be minimized with $n - g$ being the number of objectives (indicators) to be minimized.

Thus MULTIMOORA summarizes MOORA (i. e. Ratio System and Reference point) and the Full Multiplicative Form. Ameliorated Nominal Group and Delphi techniques can also be used to reduce remaining subjectivity (Brauers and Zavadskas 2010). The theory of dominance (Brauers and Zavadskas 2011) enables to classify the ranks obtained from the different parts of MULTIMOORA.

3.2. The theory of dominance

How to make a synthesis between the results of the three approaches: Ratio System, Reference Point Method, which uses the ratios obtained in the ratio system as coordinates, and the Full Multiplicative Form?

Why not the theory "Correlation of Ranks?" The method of correlation of ranks consists of totalizing ranks. Rank correlation was introduced first by psychologists such as Spearman (1904, 1906, 1910) and later taken over by the statistician Kendall in 1948. He argues (Kendall 1948: 1): "we shall often operate with these numbers as if they were the cardinals of ordinary arithmetic, adding them, subtracting them and even multiplying them," but he never gives a proof of this statement. In his later work this statement is dropped (Kendall and Gibbons 1990).

The three methods of MULTIMOORA are assumed to have the same importance. Stakeholders or their representatives like experts may have a different importance in ranking but this is not the case with the three methods of MULTIMOORA. These three methods represent all existing methods with dimensionless measures in multi–objective optimization and consequently all the three have the same important significance.

Dominance. *Absolute Dominance* means that an alternative, solution or project is dominating in ranking all other alternatives, solutions or projects which are all being dominated. This absolute dominance shows as rankings for MULTIMOORA: (1–1–1). *General Dominance in two of the three methods* is of the form with a < b < c <d:

(d–a–a) is generally dominating (c–b–b);

(a–d–a) is generally dominating (b–c–b);

(a–a–d) is generally dominating (b–b–c);

and further transitiveness plays fully.

Transitiveness. If *a* dominates *b* and *b* dominates *c* than also *a* will dominate *c*.

Overall Dominance of one alternative on the next one. For instance (a–a–a) is overall dominating (b–b–b) which is overall being dominated, with (b–b–b) following immediately (a–a–a) in rank (transitiveness is not playing).

Equability. *Absolute Equability* has the form**:** for instance (e–e–e) for 2 alternatives. *Partial Equability* of 2 on 3 exists e. g. (5–e–7) and (6–e–3).

Circular Reasoning. Despite all distinctions in classification some contradictions remain possible in a kind of *Circular Reasoning*. We can cite the case of:

Object A (11–20–14) $\succ$ Object B. (14–16–15);

Object B (14–16–15) $\succ$ Object C (15–19–12); but

Object C (15–19–12) $\succ$ Object A (11–20–14).

Here, the operator $\succ$ represents a *General Dominance*. In such a case the same ranking is given to the three objects.

4. Results

The initial data were translated in dimensionless ratios according to Eqs. 1 and 2, i. e. the Ratio System of MOORA. Subsequently Eq. 3 used the ratios obtained in Eq. 1to calculate the distances to the Reference Point of MOORA. Finally, the Full Multiplicative Form used the initial data to rank the Member States according to Eq. 4. Note that the intermediary calculations are available from the authors upon request. The following Table 2 presents the results of multi-objective optimization.

Table 2. The final ranking of the EU Member States' Economies

MULTIMOORA rank	Countries	Rank RS	Rank RP	Rank MF
1	Sweden	2	1	1
2	Luxemburg	1	7	3
3	Finland	3	5	4
4	Netherlands	5	2	7
5	Denmark	6	3	8
6	Germany	7	8	6
7	Austria	8	4	9
8	Estonia	4	16	2
9	Belgium	12	6	10
10	Slovakia	9	14	13
11	Slovenia	14	10	14
12	Lithuania	10	20	11
13	Czech Republic	11	13	15
14	France	18	9	18
15	Hungary	20	17	5
16	Latvia	15	21	12
17	Malta	17	15	17
18	Bulgaria	13	22	16
19	Poland	16	18	19
20	Cyprus	19	24	20
21	U. K.	21	11	21
22	Italy	22	12	22
23	Romania	23	23	24
24	Spain	24	19	25
25	Ireland	25	26	23
26	Portugal	26	25	26
27	Greece	27	27	27

Here the last three columns describe ranks provided by different parts of MULTIMOORA, namely Ratio System (RS), Reference Point (RP), and Full Multiplicative Form (MF). The Dominance theory described in Section 3.2 was employed to summarize these ranks into a single one which is given in the first column and all the EU Member States are arranged thereby. According to the final ranks provided by MULTIMOORA, one can distinguish between the three groups of the EU Memeber States in terms of their economic prospective.

First, Sweden, Luxemburg, Finland, the Netherlands, Denmark, Germany, Austria, Estonia, and Belgium can be considered as those peculiar with relatively stable and promising socio-economic situation and thus higher credit ratings.

Second, Slovakia, Slovenia, Lithuania, the Czech Republic, France, Hungary, Latvia, Malta, and Bulgaria are specific with mediocre positions.

Third, Poland, Cyprus, the United Kingdom, Italy, Romania, Spain, Ireland, Portugal, and Greece remain the most risky investment destinations. Indeed, serious fiscal measures are needed for most of these states in order to graduate from the last group.

It is to be noted that the Group of Tten which only joined the EU in 2004 is doing quite well and especially the countries Estonia (who even joined the Euro Group), Slovakia, Slovenia, Lithuania, and the Czech Republic. The so called PIIGS are indeed the last classified together with Romania but also the United Kingdom is not very well classified.

5. Conclusions

Instead of the expert opinion of, for instance, the rating offices like Standard & Poor's we prefer to estimate the economic worth of the European Union Member States by Multi-Objective Optimization. Therefore 22 objectives were selected to characterize each EU Member State. Next problem was the choice of an effective method of Multi-Objective Optimization. This method has to use complete and not partial aggregation, as an overall view of the countries is needed, and has to avoid the use of weights, being dual on normalization and importance. Therefore methods based on dimensionless measures are preferred. MULTIMOORA responding to all these conditions was finally chosen. In addition MULTIMOORA is composed of three approaches each controlling each other. In this way all possible methods based on dimensionless measures are included.

Having the results of the three approaches, Ratio Analysis System, Reference Point Approach and Full Multiplicative Form, the problem remains how to come to a final and unique solution. For that purpose the correlation of ranks is senseless. A Theory of Dominance is rather preferred.

The final results classify Sweden first followed by Luxemburg, Finland, the Netherlands and Denmark. Some of the ten countries, which joined the EU in 2004, are doing quite well, leaded by Estonia which even joined the EMU. As expected the PIIGS countries are classified at the bottom, but joined by an unforeseen United Kingdom.

On basis of the outcomes it would be perhaps possible, eventually with more available data and with worldwide coverage, to come to ratings comparable to the Credit Rating Agencies ratings. Further investigation in this sense could be useful.The proposed multi-criteria assessment framework can provide a rationale for interested stakeholders: government bodies and public institutions, investors, financial institutions, and business agents related with certain states. More specifically, the governments can decide on imposing some additional fiscal or monetary measures in order to improve the shrinking credit rating. The most conservative investors, in turn, should opt for long-term investments in relatively uncredible states, namely Italy, Romania, Spain, Ireland, Portugal, and Greece. Menawhile, the short-term conservative investments should be directed at Sweden, Luxemburg, Finland, the Netherlands, Denmark, Germany, Austria, Estonia, and Belgium. As for business agents dealing with uncredible states, they should consider additional means for reducing risk of insolvency there; for instance, credit insurance. Thus, a proper estimation of credit rating can improve the decisions of all the interested stakeholders and somehow mitigate their risks.

Further studies employing two-tulpe linguistic repsentation would enable to express the integrated credit rating in terms of certain linguistic scales.

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