

Evaluation of Economic Indicators of EU Countries by DEA

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Abstract: - One of the most important unions in the world with the power of directing the world economy is the European Union (EU), which has 27 members by the year 2007. Starting with 6 members in 1957, the EU expanded with new participations. Participation of other members brought up the discussion of the economical and social differences and imbalances between the member countries. This paper deals with this discussion's economical side and brings a mathematical view with Data Envelopment Analysis which is a mathematical modelling method of calculating relative efficiencies of Decision Making Units (DMUs), based on predetermined inputs and outputs. DMUs are the EU member countries and inputs-outputs are economic indicators. After finding the relative efficiencies of the member countries, the results are discussed.

Key-Words: - EU, DEA, Economic Indicators

1 Introduction

One of the most important unions in the world with the power of directing the world economy is the European Union (EU), which has 27 members by the year 2007. The history of the EU begins in 1950s, the union, which was originally established by six countries is on the way to being the economical and political center of the world [1]. After the second world war, The Schuman Declaration, based on a plan by Jean Monnet and signed on 9 May 1950, gave rise to the European Coal and Steel Community (ECSC) with the aim of integration of the markets for the industrial resources necessary for reconstruction of Europe, and production of weapons of war. The founding members of the community were Belgium, Netherlands, Luxembourg France, Italy and West Germany. Two additional communities were created by the Treaties of Rome in 1957; the European Economic Community (EEC), establishing a Customs Union and the European Atomic Energy Community (EAEC or Euratom) for cooperation in nuclear energy. The ECSC and Euratom were merged into the EEC in 1967 with the Merger Treaty. They had a single membership with a combined set of treaties and institutions, and the collective was referred to as the European Communities (now, the European Community, within the EU). The Copenhagen Criteria agreement and the Maastricht Treaty formally established the EU on 1 November 1993. With that treaty, the European Community became one of three pillars of the EU, alongside new areas of integration: foreign policy and interior affairs. In 1999 the euro was introduced for bank transfers, and euro coins and banknotes replaced national currencies in 12 of the member states in 2002.

The European Union involves union of political, cultural and economical issues, as if being a unique country with different cities. The EU is trying to keep a specific level on some country development indicators and therefore has some criteria for the candidate countries. On seeing the power and high prosperity of the EU, countries within the European borders, are applying for membership. These applications have always been a topic of discussion because of keeping the aforesaid levels of economic and social indicators. The huge union of 27 countries includes members having different indicator values. The aim of this paper is to evaluate the countries on the basis of economic indicators by Data Envelopment Analysis (DEA). The reason of using DEA is that because it is an objective method based on mathematical modeling and on relative efficiencies.

The composition of the paper involves firstly the review of Data Envelopment Analysis method, then the economic indicator data, following the application of model and lastly concluding remarks.

2 Data Envelopment Analysis

DEA was first introduced by Charnes and Cooper (1978) as a linear programming (LP)-based methodology for performing analysis of how efficiently a company operates [2]. DEA is composed of several mathematical models sharing the principle of envelopment. The objective of DEA is to assess the relative efficiency of a variety of decision making units (DMUs) using a variety of input and output data; the term "relative" is important since a DMU that is efficient in a given data set may be inefficient in another data set [3]. The requirement for

the DMUs is that they should use similar inputs and produce similar outputs and they should be quantifiable, the method does not require transformation of units [4]. DEA is a powerful aggregate comparative method for assessing the productivity of organizations with multiple incomparable inputs and outputs [5].

3 Economic Indicators

The economic indicators determined for evaluation are: GDP per capita (purchasing power parity) (\$), inflation rate (consumer prices) (%), unemployment rate (%) and population growth rate (%). GDP gives the gross domestic product (GDP) or value of all final goods and services produced within a nation in a given year. A nation's GDP at purchasing power parity (PPP) exchange rates is the sum value of all goods and services produced in the country valued at prices prevailing in the United States [6]. In this research GDP per capita is used, therefore it is calculated by dividing the GDP by the

population. Population growth rate, which is the third input, is the average annual percent change in the population, resulting from a surplus (or deficit) of births over deaths and the balance of migrants entering and leaving a country, the growth rate is a factor in determining how great a burden would be imposed on a country by the changing needs of its people for infrastructure (e.g., schools, hospitals, housing, roads), resources (e.g., food, water, electricity), and jobs [6]. Inflation rate by consumer prices gives the annual percent change in consumer prices compared with the previous year's consumer prices and unemployment rate contains the percent of the labor force that is without jobs. The economic indicator values of the 27 member countries are seen in Table 1. All of the GDP, inflation and unemployment values - except for Cyprus inflation rate and Malta unemployment rate, which are 2005 estimate values- are 2006 estimate values [6] and the population growth rates are 2007 estimate values.

Table 1. Economic indicator values of EU member countries

COUNTRY	GDP – per capita (PPP) \$	Inflation rate (consumer prices) (%)	Unemployment rate (%)	Population growth rate (%)
Austria	34600	1,60	4,90	0,077
Belgium	33000	2,10	8,10	0,120
Bulgaria	10700	6,50	9,60	-0,837
Cyprus	23000	2,80	5,50	0,527
Czech Republic	21900	2,70	8,40	-0,071
Denmark	37000	1,80	3,80	0,311
Estonia	20300	4,40	4,50	-0,635
Finland	33700	1,70	7,00	0,127
France	31100	1,50	8,70	0,588
Germany	31900	1,70	7,10	-0,033
Greece	24000	3,30	9,20	0,163
Hungary	17600	3,70	7,40	-0,253
Ireland	44500	3,90	4,30	1,143
Italy	30200	2,30	7,00	0,010
Latvia	16000	6,80	6,50	-0,648
Lithuania	15300	3,80	5,70	-0,289
Luxembourg	71400	2,60	4,10	1,207
Malta	21000	2,60	6,80	0,413
Netherlands	32100	1,40	5,50	0,464
Poland	14300	1,30	14,90	-0,046
Portugal	19800	2,50	7,60	0,334
Romania	9100	6,80	6,10	-0,127
Slovakia	18200	4,40	10,20	0,147
Slovenia	23400	2,40	9,60	-0,065
Spain	27400	3,50	8,10	0,116
Sweden	32200	1,40	5,60	0,159
United Kingdom	31800	3,00	2,90	0,275

4 Application Of The Model

In order to apply the DEA model, firstly the input and outputs should be determined. The economic indicators are determined above as, GDP per capita (purchasing power parity) (\$), inflation rate (consumer prices) (%), unemployment rate (%) and population growth rate (%). The first one is decided to be the output, and the respectives are decided to be the inputs. GDP, the market value of all goods and services produced within the borders of a country, is the most widely used measure of overall economic activity both across countries and within countries over time [7], therefore GDP has been selected as output, which is the value to be produced at the end, as high as possible. Maintaining a low and stable inflation rate has become one of the challenges in the macroeconomic management of most countries, and has been a country development measure [8]. The countries with low inflation are generally developed countries and those with high inflation rate are generally underdeveloped or developing countries. One of the most important issues that European Union (EU) countries have to overcome is the problem of unemployment; unemployment has increased from 4 percent in the 1960s to over 10 per cent in the 1990s [9]. It again fell under 10 percent in the recent years, but it is still a big problem for the countries and an important indicator for economic situation of a country. The focus of all indicators is actually the population growth since increase in population forces the country economics in many ways such as increasing the investments. Also high population of the member country will increase the population of the union, which is not wanted by the EU. These three indicators are decided to be inputs, because they produce the output, GDP and they should be as low as possible.

The evaluation of the member countries are made by DEA because of its objectivity property. As it is stated above, DEA is a method of evaluating decision making units (DMUs), here the member countries, by calculating their relative efficiencies. This means that the countries' efficiencies regarding the determined input and output values are calculated relative to each other, in other words in the given data set. The enveloped DEA model by input is written as follows:

$$E_k = \text{Min } \alpha - (\sum_{i=1}^m s_i^- \cdot n) \epsilon + \sum_{r=1}^p s_r^+ \quad (\text{equation 1})$$

$$\sum_{j=1}^n X_{ij} \lambda_j - (s_i^- \cdot \alpha) = 0 \quad (\text{equation 2})$$

$$\sum_{j=1}^n X_{rj} \lambda_j - (s_r^+ \cdot Y_{rk}) = 0 \quad (\text{equation 3})$$

$$s_r^+, s_i^-, \lambda_j \geq 0$$

- Ek = efficiency of the kth DMU
- Xij = ith input used by jth DMU
- Xik = ith input used by kth DMU
- Xrj = rth output produced by jth DMU
- Yrk = rth output produced by kth DMU
- ε = a very small positive number
- n = DMU number
- p = output number
- m = input number
- α = shrinkage coefficient
- si- = slack value of the ith input of kth DMU
- sr+ = slack value of the rth output of kth DMU
- λj = intensity value of the jth DMU

The model is written for each DMU, country. There are 27 countries, therefore k=27. There is one output, therefore p=1 and there are three inputs and m=3. The result values, after solving the 27 models, are seen in Table 2. Austria, Estonia, Germany, Luxembourg and Sweden are found the as the efficient DMUs, relative to other countries and the other countries are found inefficient. This means that these 5 efficient countries have the highest GDP regarding their smaller inflation rates, unemployment rates and population growth rates. Luxembourg and (West) Germany were two of the establishing members of the EU, while other establishing members were Belgium, France, Italy and Netherlands. Netherlands is the fifth in the list in Table 2 with the efficiency 0.890, France is the sixth with the efficiency 0.781, Belgium is the seventh with the efficiency 0.720 and Italy is the eighth with the efficiency 0.709. If we look at the first ten countries (assuming the countries with 1.0 efficiency at the first rank) and their participation years, the facts are such: Austria (1995), Estonia (2004), Germany (1957 and 1990 association of west and east Germany), Luxembourg (1957), Sweden (1995), Denmark (1973), United Kingdom (1973), Finland (1995), Netherlands (1957), France (1957), Belgium (1957), Italy (1957), Poland (2004), Ireland (1973). The remainig countries, except for Spain and Portugal, which joined the union in 1986 and Greece, which joined the union in 1981, joined the union after 2004.

It is difficult to make an interpretation about the relation between the participation date and the economic indicator performance. But it is seen that the recently member countries have relatively low efficiencies. This may possibly explain the discussions of accepting new members to the union and the discussions about decreasing the prosperity level of the union.

Table 2. Country efficiency values

Country	Efficiency Value
Austria	1,000
Estonia	1,000
Germany	1,000
Luxembourg	1,000
Sweden	1,000
Denmark	0,992
United Kingdom	0,953
Finland	0,894
Netherlands	0,890
France	0,781
Belgium	0,720
Italy	0,709
Poland	0,649
Ireland	0,625
Slovenia	0,545
Czech Republic	0,492
Spain	0,455
Lithuania	0,430
Latvia	0,429
Hungary	0,409
Cyprus	0,402
Greece	0,360
Malta	0,353
Portugal	0,345
Bulgaria	0,258
Slovakia	0,240
Romania	0,185

For instance, Luxembourg's GDP is the highest among the others with 71400 USD. On the other hand, its inputs are not the smallest ones, but the relative ratio is the greatest one therefore it is found relatively efficient among others. This result could also be foreseen by looking at the indicator values of countries in Table 1. As it is known, the main idea of efficiency is producing more output by using less inputs, therefore the aim is to maximize the output/input ratio. In Table 3, output input ratios are given for the countries. The DEA results in Table 2 are the composite ranking of the rankings regarding input 1-3, because DEA finds out the efficiency according to all inputs.

Table 3. Output/Input ratios

Country	Output/Input 1	Output/Input 2	Output/Input 3
Luxembourg	27462	17415	449351
Sweden	23000	10966	275000
Netherlands	22929	10349	-12784
Austria	21625	9737	43643
France	20733	7061	-308451
Denmark	20556	5836	118971
Finland	19824	5750	-31969
Germany	18765	4814	265354
Belgium	15714	4511	52891
Italy	13130	4493	-966667
Ireland	11410	4314	147239
Poland	11000	4182	-69565
United Kingdom	10600	4074	38933
Slovenia	9750	3575	3020000
Cyprus	8214	3383	-24691
Czech Republic	8111	3088	-52941
Malta	8077	2684	59155
Portugal	7920	2609	50847
Spain	7829	2607	69181
Greece	7273	2605	-310870
Hungary	4757	2462	59281
Estonia	4614	2438	-71654
Slovakia	4136	2378	123810
Lithuania	4026	1784	-360000
Latvia	2353	1492	236207
Bulgaria	1646	1115	202516
Romania	1338	960	115636

5 Conclusion And Further Research

This paper evaluates the economic indicators of the EU member countries by data envelopment analysis, a mathematical modelling method. Starting with 6 members in 1957, the EU has 27 members by 2007. Application of other members brought up the discussion of the economical and social differences and imbalances between the member countries. These applications have always been a topic of discussion because of keeping the levels of economic and social indicators. The aim of this paper is to make an explanation to these discussions' economical side by evaluating the countries on the basis of economic indicators by Data Envelopment Analysis (DEA). The economic indicators are determined as, GDP per capita (purchasing power parity) (\$), inflation rate (consumer prices) (%), unemployment rate (%) and population growth rate (%). Since DEA is based on

output input values, these indicators are categorized. The first one is decided to be the output, and the respective are decided to be the inputs. GDP has been selected as output, which is the value to be produced at the end, as high as possible. The other two indicators are decided to be inputs, because they produce the output, GDP and they should be as low as possible.

DEA is selected for this analysis, because it is an objective mathematical method and compares the DMUs (namely the EU members here) relatively. It is based on output-input values and finds relative efficiencies on the given data set. After forming the models and solving them for each DMU, Austria, Estonia, Germany, Luxembourg and Sweden are found efficient relative to other countries and all the other countries are found inefficient, which means that Luxembourg has the highest GDP per capita regarding its smaller inflation rate, unemployment rate and population growth rate. These countries became members of the union before 1995, additionally Luxembourg and Germany are the establishing members. Returning to the discussion of decreasing the prosperity level of EU by the participation of new members, the participation years and efficiency values are compared. Since it is difficult to make an interpretation about the relation between the participation date and the economic indicator performance, it is seen that the recently member countries have relatively low efficiencies. This may possibly explain the discussions of accepting new members to the union and the discussions about decreasing the economic performance of the union. Additionally this paper makes a comparison of the DEA results with the simple efficiency formula. As it is known, the main idea of efficiency is producing more output by using less inputs, therefore the aim is to maximize the output/input ratio. The rankings of the members found from separately calculated output input ratios for the countries and the DEA results are mostly similar with some exceptions. The DEA results are the composite rankings of the rankings regarding input 1-3, because DEA finds out the efficiency according to all inputs.

Further research can be conducted on some other indicator values and on different years' values, i.e. taking the last 20 years values and seeing the performance among years can be beneficial. Another research can be conducted by making different combinations of inputs and outputs.

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