Evaluating the Impact Of European Union On The Existing And Newly-Joining Nations Using Data Envelopment Analysis

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Abstract

Using data envelopment analysis approach, this study compares the relative performance of European Union (EU) 28 nations against one another with seven economic variables as the benchmark parameters from 1999 to 2006. We find that all the participating nations were not equally efficient at the beginning of the economic integration in 1999. Economic integration did help in achieving convergence in economic performance of EU 28 nations, because seventeen of the twenty eight nations were efficient in 2002. However, this study finds that after 2002, there is lack of convergence in the performance of EU 28 nations and some nations have performed more efficiently in contrast to other nations. The study points out the member nations that are lagging behind and make recommendations as to how they can improve their performance to bring them at par with other participating nations.

1. Introduction

The guiding principle behind economic integration/economic union is the concept of convergence in per capita income and/or per worker income among participating nations. European Union (EU) was created with this basic principle in mind. By making conditions equal across Europe, EU will be able to bridge the gap between the rich and poorer nations. Over the last fourteen years, EU has tried to create equal opportunities for the poorer nations and we try to find out if it helped poorer nations get richer and closer to rich nations in terms of GDP per capita as well as in terms of absolute amount of GDP. The purpose of this paper is to provide some comparative perspective on the growth rates of the original fifteen member nations of the European Union (EU). This study measures the effectiveness of the integration of Europe by benchmarking economic progress made by the original fifteen participating nations. In this paper, we use the *Data Envelopment Analysis* methodology to assess the relative performance of the 28 EU nations from 1999 to 2006. This paper builds on a previous study by Malhotra, Malhotra, and Mariotz (2005) (MMM hereafter) in which they benchmark European Union nations for the year 2004 only. We distinguish current study from MMM (2005)'s study by adopting a much larger database from January 1993 to January 2006. This will help us in tracking the progress made by the European Union in achieving convergence of economic performance of all the participating nations over a period of fourteen years.

Furthermore, by benchmarking European Union nations against one another for each of the last fourteen years, we will be able to find out if some nations have consistently performed well under the EU. By identifying the nations that have performed consistently well over a period of fourteen years, we can identify the factors that have contributed to their success so that other EU nations can structure their policies to benefit from economic integration. It will also help us track and understand the changes in performance of the EU over a period of time. Furthermore, we also investigate any trends in the performance of these countries over the last fourteen years.

The rest of the paper is organized along the following lines. Section II provides a summary of the previous literature on the European Union. We also include previous studies on applications of data envelopment analysis. In section III, we discuss the methodology used in this study. Section IV summarizes the empirical results. Section V provides summary and conclusion for this study.

2. Previous Studies

2.1 European Union Literature

Canova and Marcet (1995) study income convergence across European countries and report a high convergence rate, especially among members of the European Union countries. Paliwoda (1997) present selected statistics on Central and Eastern Europe to reflect the respective levels of current economic performance as well as expert projections as to where these economies are headed. According to Paliwoda (1997), a common objective shared by many Central and Eastern European nations is membership of the European Union together with the NATO defense alliance, so as to be better able to consolidate economic and political gains made to date. Canova (1999) analyzes the impact of EU's structural policies on the income disparities between countries and regions. Grimwade (1999) discusses the growth of the European Union and documents higher growth in the Eurozone after the integration. Wynne (2000) looks at how the economy of the euro area has fared under the single monetary policy, examines how successful the European Central Bank has been in fulfilling its mandate for price stability, and considers the prospects for the future. Despite the dramatic decline in the euro against the dollar over the course of 1999, the first year of EMU must be judged a success. Boldrin and Canova (2001) examine if EU subsidies help regions grow and bridge the gap between rich and poor regions. Garcia-Mila and McGuire (2001) evaluate the seventeen regional governments of Spain that receive grants from the European Union. This study evaluates the effectiveness of these grants and finds that these policies have not been effective in stimulating private investment or improving the overall economies of the poorer regions. Amuedo-Dorantes and Wheeler (2001) examines the impact that the European Union (EU) has exerted on Spanish economic activity. The main finding of the analysis is that the EU has significant impacts on the Spanish economy. The paper finds that shocks to EU output explain up to 63% of Spanish output. At longer time horizons, shocks to the EU's inflation rate and output combine to explain over 50% of the forecast error variance in Spanish inflation. Gacs (2003) analyzes how much and to what direction the inherited structure of the Central and East European candidate countries was transformed in recent years, and what this shift meant for their real convergence in the enlarged EU. A rearrangement of historical importance occurred across the main sectors contributing to GDP, in the framework of which services have been emancipated. Salih (2004) argues that the road to EU as a nation will not be as smooth as some European countries would have hoped. Structural incompatibilities, political rivalry and speculator's behavior are some of the factors that will affect the performance and unification of Europe. Ultimately, cooperation between rival nations is a vital factor to a successful unification of Europe, better global well being and trade and development. Malhotra and Mariotz (2005) measure the effectiveness of the integration of Europe by evaluating economic and socioeconomic progress made by fifteen participating nations since the Maastricht Treaty. They find that on the economic front, member nations have made good progress during the post-Maastricht Treaty period. However, on the socio-economic front, during the post-Maastricht Treaty, many member nations show deterioration in the performance. Beugelsduk (2005)'s study investigates whether there is evidence of convergence in the growth rates of current EU countries. The study also analyzes the role of structural funds allocated by the European Union in bringing about convergence.

2.2. Data Envelopment Analysis Literature

Recently, many studies have illustrated the use of DEA, a non-parametric methodology to analyze different aspects of mutual funds. The details of the DEA model are discussed in the next section. In contrast to other methodologies, DEA is one of the methods that have traditionally been used to assess the comparative efficiency of homogenous operating units such as schools, hospitals, utility companies, sales outlets, prisons, and military operations. More recently, it has been applied to banks (Haslem, Scheraga, & Bedingfield, 1999) and mutual funds (Haslem & Scheraga, 2003; Galagedera & Silvapulle, 2002; McMullen & Strong, 1998; Murthi, Choi, & Desai, 1997).

Murthi, Choi, & Desai (1997) examine the market efficiency of the mutual fund industry by different investment objectives. They use a benefit/cost non-parametric analysis where a relationship between return (benefit) and expense ratio, turnover, risk, and loads (cost) is established. They also develop a measure of performance of mutual funds that has a number of advantages over traditional indices. The DEA portfolio efficiency index (DEPI) does not require specification of a benchmark, but incorporates transaction costs. The most important advantage of DEA method as compared to other measures of fund performance is that DEA identifies the variables leading to inefficiencies and the levels by which they should be changed to restore the fund to its optimum level of efficiency. McMullen and Strong (1998) applied DEA to evaluate the relative performance of 135 US common stock funds using one, three, and five-year annualized returns, standard deviation of returns, sales charge, minimum initial investment, and expense ratio. They illustrate that DEA can assist in selecting mutual funds for an investor with a multifactor utility function. The DEA selects optimum combinations of investment characteristics, even when the desired characteristics are other than the two-factors specified in Capital Market Theory. The DEA enable the user to determine the most desirable alternatives, and pinpoint the inefficiencies in a DEA-inefficient alternative. Sedzro and Sardano (1999) analyzed 58 US equity funds in Canada using DEA with annual return, expense ratio, minimum initial investment and a proxy for risk as factors associated with fund performance. Further, they also find a strong relationship among the efficiency rankings using DEA, Sharpe ratios, and Morningstar data. Galagedera and Silvapulle (2002) use DEA to measure the relative efficiency of 257 Australian mutual funds. The further investigate the sensitivity of DEA efficiency to various input-output variable combinations. They find that more funds are efficient when DEA captures a fund's long-term growth and income distribution than a shorter time horizon. In general, the overall technical efficiency and the scale efficiency are higher for risk-aversive funds with high positive net flow of assets.

Haslem and Scheraga (2003) use DEA to identify efficiencies in the large-cap mutual funds in the 1999 Morningstar 500. They identify the financial variables that differ significantly between efficient and inefficient funds, and determine the nature of the relationships. They use Sharpe index as the DEA output variable. They find that the input/output and profile variables are significantly different between the Morningstar 500 (1999) large-cap mutual funds that are DEA performance-efficient and inefficient. Basso and Funari (2001) propose the use of DEA methodology to evaluate the performance of mutual funds. The proposed DEA performance indexes for mutual funds represent a generalization of various traditional numerical indexes that can take into account several inputs and outputs. They propose two classes of DEA indexes. The first class generalizes the traditional measures of evaluation using different risk indicators and subscription and redemption costs that burden the fund investment. The second class of indexes considers a multiple inputs-outputs structure. Thus, they monitor not only the mean return but also other features such as stochastic dominance and the time lay-out. Morey and Morey (1999) present two basic quadratic programming approaches for identifying those funds that are strictly dominated, regardless of the weightings on different time horizons being considered, relative to their mean returns and risks. They present a novel application of the philosophy of data envelopment analysis that focuses on estimating "radial" contraction/expansion potentials. Furthermore, in contrast to many studies of mutual fund's performance, their approach endogenously determines a custom-tailored benchmark portfolio to which each mutual fund's performance is compared.

Using data envelopment analysis approach, Malhotra, Malhotra, and Mariotz (2005) compare the relative performance of EU 15 nations against one another with seven economic variables as the benchmark parameters. Using the data for January 2003 MMM's study finds that there is lack of convergence in the performance of EU 15 nations and some nations have performed more efficiently in contrast to other nations. The purpose of this study is to investigate and analyze the relative performance of the original and newly participating countries in the European Union since inception of the European Union. Using the economic data from 1999-2006, this study illustrates the use of data envelopment analysis (DEA) to evaluate the homogeneity of benefits of integration across the members of the European Union over the last seven years.

3. Methodology

The data for this study is obtained from *Countrydata.com*. Seven economic variables are used to evaluate the impact of European integration on the participating nations.
The variables have been defined by *Countrydata.com* as follows:

- **Current Account as Percentage of Gross Domestic Product (GDP)**: Estimated balance on the current account of the balance of payments, converted into US dollars at the average exchange rate for the year, expressed as a percentage of GDP, converted into US dollars at the average rate of exchange for the period covered.
- **Current Account as Percentage of Exports (XGS)**: Estimated balance on the current account of the balance of payments, converted to US$ at average rate, expressed as a percentage of total exports of goods and services (XGS), converted into US$ at exchange rate for period covered.
- **GDP per Head of Population**: Gross domestic product per head of population, converted into US dollars at the average exchange rate for that year.
- **Inflation**: Estimated annual inflation rate, expressed as the weighted average of the Consumer Price Index and calculated as a percentage change.
- **International Liquidity**: Estimated annual net liquidity expressed as months of cover and calculated as the official reserves of the individual countries, including their official gold reserves calculated at current free market prices, but excluding the use of IMF credits and the foreign liabilities of the monetary authorities.
- **Real GDP Growth:** Annual change in estimated Gross Domestic Product, at a constant 1990 prices (for data in the 1990s), of a given country is expressed as a percentage increase or decrease.

- **Exchange Rate Stability**: It is measured by the annual percentage change in the exchange rate of the national currency against the US dollar (against the euro in the case of the US).

Table 2 presents the key characterisitics of the data such as mean, media, standard deviation, maximum, minimum, and range for the years 1999 and 2006. As evident from the last three rows for both years, the EU countries illustrate significant variation in the economic metrics. Figure 1 illustrates the data for the year 2006 in pictorial form.

3.1. Data Envelopment Model Specifications for European Union

Besides the mathematical and computational requirements of the DEA model, there are many other factors that affect the specifications of the DEA model. These factors relate to the choice of the DMUs for a given DEA application, selection of inputs and outputs, choice of DMUs for a given DEA application, selection of inputs and outputs, choice of a particular DEA model (e.g. CRS, VRS, etc.) for a given application, and choice of an appropriate sensitivity analysis procedure (Ramanathan, 2003). Due to DEA's non parametric nature, there is no clear specification search strategy. However, the results of the analysis depend on the inputs/outputs included in the DEA model. There are two main factors that influence the selection of DMUs – homogeneity and the number of DMUs. To successfully apply the DEA methodology, we should consider homogenous units that perform similar tasks, and accomplish similar objectives. In our study, the countries are homogenous as they became part of the European Union. Furthermore, the number of DMUs is also an important consideration. In addition, the number of DMUs should be reasonable so as to capture high performance units, and sharply identify the relation between inputs and outputs. The selection of input and output variables is the most important aspect of performance analysis using DEA. In general, the inputs should reflect the level of resources used or a factor that should be minimized. The outputs reflect the level of the economic variable factor, and the degree to which an economic variable contributes to the overall strength (efficiency) of a country. There are some simple rules of thumb that guide the selection of inputs and outputs, and the number of participating DMUs[1].

To study the performance of European Union countries, we consider seven factors: current account as percentage of GDP, current account as a percentage of XGS, inflation, GDP per head of population, real GDP growth rate, international liquidity, and exchange rate stability. Out of these seven factors, we specified inflation as input, because if a country is able to keep inflation down, it is an indicator of superior performance within the framework of the European Union guidelines. All other factors will be considered as output factors as a higher value of these variables improves the efficiency or performance of the country. Finally, the choice of the DEA model is also an important consideration. We should select the appropriate DEA model with options such as input maximizing or output minimizing, multiplier or envelopment, and constant or variable returns to scale. DEA applications that involve inflexible inputs or not fully under control inputs should use output-based formulations. On the contrary, an application with outputs that are an outcome of managerial goals, input-based DEA formulations are more appropriate. In addition, for an application that emphasizes inputs and outputs, we should use multiplier version. Similarly, for an application that considers relations among DMUs, envelopment models are more suitable. Furthermore, the characteristics of the application dictate the use of constant or variable returns to scale. If the performance of DMUs depends heavily on the scale of operation, constant returns to scale (CRS) is more applicable, otherwise variable returns to scale is a more appropriate assumption.

In our study, the relationship among the European Union nations is an important consideration. Therefore, we select

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[1] The following are the guidelines for DMU model selection:

a. The number of DMUs is expected to be larger than the product of number of inputs and outputs (Darrat et. Al., 2002; Avkiran, 2001) to discriminate effectively between efficient and inefficient DMUs. The sample size should be at least 2 or 3 times larger than the sum of the number of inputs and outputs (Ramanathan, 2003).

b. The criteria for selction of inputs and outputs are also quite subjective. A DEA study should start with an exhaustive, mutual list of inputs and outputs that are considered relevant for the study. Screening inputs and outputs can be quite quantitative (e.g. statistical) or qualitative that are simply judgmental, use expert advice, or use methods such as analytical hierarchy process (Saaty, 1980). Typically inputs are the resources utilized by the DMUs or condition affecting the performance of DMUs. On the other hand, outputs are the benefits generated as a result of the operation of the DMUs, and records higher performance in terms of efficiency. Typically, we should restrict the total number of inputs and outputs to a reasonable level. As the number of inputs and outputs to a reasonable level. As the number of inputs and outputs increases, more number of DMUs get an efficiency rate of 1, as they become too specialized to be evaluated with respect to other units (Ramanathan, 2003).

the envelopment models for our analysis. In addition, inflation is not a very flexible input that cannot be immediately controlled. Therefore, output-based formulation is recommended for our study. The objective of the analysis is to suggest a benchmark for the economic variables given a certain inflation value. Furthermore, the performance of the EU nations does not depend on the scale of operations, thus variable returns to scale is safe assumption. Also, the structure of the DEA model (in envelopment form) uses an equation and separate calculation for every input and output. Therefore, all the input and output variables can be used simultaneously and measured in their own units. In this study, we use two DEA models – Constant Returns to Scale (CRS) to evaluate the overall efficiency score and Variables Return to Scale (VRS) to evaluate the technical and the scale efficiencies for the year 2006.

4. Empirical Analysis

Each of the EU nations is a homogenous unit, and we can apply the DEA methodology to assess a comparative performance of these countries. The study evaluates the impact of the EU integration on achieving prosperity by tracking the gains (or losses) made by each member nation on economic front for each of the original 15 states of the union. Using the DEA methodology, we can calculate an efficiency score for the 28 nations on a scale of 1 to 100. We analyze and compute the efficiency of the EU nations for the period 1999-2006. Table 3 illustrates the efficiency scores of the 28 original and newly-added states of the union from the year 1999-2006.Further, we also study the peers (model countries) for inefficient countries.

Table 3 shows the progress made by the European Union nations in achieving convergence in economic performance of all participating nations. Table 3 shows that only thirteen out of twenty eight countries were ranked efficient in 1999, but in 2002 seventeen out of twenty eight nations were efficient, and except three nations the remaining nations were inefficient by a small margin only. The average efficiency level increased from 84% in 1999 to 94% in 2004, and again decreases to 86% in 2006. Table 4 shows the efficiency scores of all the participating EU nations in the year 1999 along with their rankings.

We present the score in percentage value varying between 0% and 100%. We find that the output efficiency of Estonia, Sweden, Malta, Ireland, Slovenia, Finland, Cyprus, Spain, Greece, Latvia, Denmark, Lithuania, and Netherlands is 100%. On the other hand, the output efficiency of the remaining nations are: Austria - 99.25% (1.01), Belgium – 97.19% (1.03), France – 96.78% (1.03), Germany – 87.34% (1.14), Croatia – 86% (1.16), Poland – 82% (1.22), Italy – 82% (1.22), Slovak Republic – 79% (1.27), United Kingdom – 75% (1.32), Hungary – 74% (1.34), Bulgaria – 58% (1.73), Portugal – 55% (1.82), Czech Republic – 48% (2.08), Turkey – 23% (4.27), and Romania – 19% (5.37). This means that the observed levels of current account as percentage of exports, exchange rate stability, current account as percentage of GDP, GDP per head of population, international liquidity, and real GDP growth are 1.01 times the maximum output level that Austria can secure with its current inflation rate. The same rationale applies to Belgium, France, Germany, Croatia, Poland, Italy, Slovak Republic, United Kingdom, Hungary, Bulgaria, Portugal, Czech Republic, Turkey, and Romania. Table 5 illustrates the efficiency scores and the corresponding ranking of both the original and newly participating nations in the year 2006. The average score is 86%, with sixteen nations having efficiency levels above average while the remaining twelve are below the average level. Thirteen nations turned out to be the best practices.

The best practices nations: Denmark, Finland, Ireland, Sweden, United Kingdom, Cyprus, Czech Republic, Latvia, Lithuania, Poland, Romania, Slovak Republic, and Turkey are 100% efficient. Austria, Slovenia, Bulgaria, Germany, Netherlands, Croatia, Greece, Belgium, France, Malta, Estonia, Hungary, Spain, Italy, and Portugal are inefficient. Table 5 lists there output efficiency scores and percentage efficiency score. Figure 2 illustrates the trend in the graphical form for all countries from the year 1993 to 2006. As Austria, Slovenia, Bulgaria, Germany, Netherlands, Croatia, Greece, Belgium, France, Malta, Estonia, Hungary, Spain, Italy, and Portugal are inefficient; the next step is to identify the efficient peer group or countries whose operating practices can serve as a benchmark to improve the performance of these countries.

Table 6 illustrates the peer group for the inefficient countries.

As shown in the Table 6, Denmark, and Ireland serve as peer for Austria. In addition, Austria is more comparable to Denmark (weight 78%) and less comparable to it's more distant peer Denmark (22%). Thus, Austria should scale up its GDP growth, exchange rate stability, international liquidity and other factors to make them comparable with Denmark. Similarly, Belgium has Denmark as the closest peer that it should emulate and Sweden as the distant peer country that can also be investigated. France has Denmark (89%) as its immediate peer and Ireland (11%) as its distant peer. Similarly, Germany has Denmark, Finland, and Sweden as its peers. Greece has Ireland and Latvia as its peers. Italy is 61% efficient and has Ireland as its immediate peer, and Denmark as its distant peer. Netherlands has Denmark, Sweden, and Finland as its immediate peers in decreasing order. Portugal has Denmark as its closest peer and Ireland as its distant peer. Spain has Ireland, Cyprus, and Latvia as its reference nations. Bulgaria has Cyprus and Latvia as its peers. Croatia should refer to Cyprus, Latvia, and Lithuania. Estonia and Hungary has Ireland, Cyprus, and Latvia as its peers. Malta has Finland, Cyprus, and Latvia as its peers. Finally, Slovenia has Cyprus and Sweden as its closest peerr, and Latvia and Poland as its distant peers. Finally, Denmark serves as the closest peer, and the second closest peer for all the inefficient countries. Similarly, Ireland, Cyprus, and Latvia serve as the most immediate or immediate peer for most of the inefficient countries. On the other hand, Sweden, Lithuania, and Finland are also distant peers for four, three, and one of the inefficient countries respectively. Therefore, Denmark and Ireland are the most efficient country among all the European Union countries as not only are Denmark and Ireland 100% efficient, but they also serve as the role model for all other countries. Similarly, Cyprus and Latvia are the next most efficient country among the group of EU countries. Cyprus serves as the immediate peer for Bulgaria, Croatia, Malta, and Slovenia and next immediate or farther immediate peer for Hungary and Estonia. Latvia is the immediate peer for Bulgaria, Estonia, and Hungary and distant or far-distant peer for Greece, Malta, Bulgaria, Croatia, Spain, and Slovenia. The results are quite expected as the newly participating nations have similar characteristics. Finland serves as the immediate peer country for Germany and farther immediate peer country for Netherlands and Malta as the characteristics of Germany and Netherlands also resemble Finland. Thus, Finland is the next most efficient country among the EU nations. Finally, Sweden serves as the next immediate peer for Netherlands, Slovenia, and Germany and the farthest immediate peer for Belgium. Again, this is quite expected as the characteristics of Belgium, Germany, and Netherlands match Sweden. Thus, Sweden is the last in the list of the most efficient countries in the year 2006. The efficient peer countries have a similar mix of input-output levels to that of the corresponding inefficient country, but at more absolute levels. The efficient countries generally have higher output levels relative to the country in question. The features of efficient peer countries make them very useful as role models inefficient countries can emulate to improve their performance. Furthermore, Denmark is the immediate efficient peer for five countries, so its frequency of use as an efficient-peer, expressed as a percentage of the number of pareto-inefficient countries, is 46.67%. Ireland is an efficient peer to eight countries with a frequency rate of 53.34%. However, Ireland is the most efficient peer for only three countries. Therefore, Ireland can be considered as the next most efficient country. Similarly, Latvia and Cyprus serve as the immediate most efficient country for three countries and distant or far-distant peer for four countries. Therefore, Latvia and Cyprus are the next efficient countries in the list with an efficiency frequency of 46.67%. In addition, Sweden and Finland have the peer efficiency frequencies of 26.67% and 20% respectively. Thus, we have enhanced confidence that Denmark and Ireland are genuinely well performing countries as they outperform all the other countries. Furthermore, these countries are more likely to be a better role model for less efficient countries to emulate because their operating practices and environment match more closely those of the bulk of countries. Table 7 displays the benchmarking factor and the hit percentage of efficient country.

After calculating the efficiency of a country using DEA, and identifying the efficient peers, the next step in DEA analysis is feasible expansion of the output or contraction of the input levels of the country within the possible set of input-output levels. The DEA efficiency measure tells us whether or not next country can improve its performance relative to the set of countries to which it is being compared. Therefore, after maximizing the output efficiency, the next stage involves calculating the optimal set of slack values with assurance that output efficiency will not increase at the expense of slack values of the input and output factors. Once efficiency has been maximized, the model does seek the maximum sum of the input and output slacks. If any of these values is positive at the optimal solution to the DEA model that implies that the corresponding output of the country (DMU) can improve further after its output levels have been raised by the efficiency factor, without the need for additional input. If the efficiency is 100% and the slack variables are zero, then the output levels of a country cannot be expanded jointly or individually without raising its input level. Further, its input level cannot be lowered given its output levels. Thus, the countries are pareto-efficient with technical output efficiency of 1. If the country is 100% efficient but one slack value is positive at the optimal solution then the DEA model has identified a point on the efficiency frontier that offers the same level on one of the outputs as country A in question, but it offers in excess of the country A on the output corresponding to the positive slack. Thus, country A is not Pareto-efficient, but with radial efficiency of 1 as its output cannot be expanded jointly. Finally, if the country A is not efficient (<100%) or the efficiency factor is greater than 1, then the country in question is not Pareto-efficient and efficiency factor is the maximum factor by which both its observed output levels can be expanded without the need to raise its output. If at the optimal solution, we have not only output efficiency > 1, but also some positive slack, then the output of country A corresponding to the positive slack can be raised by more than the factor output efficiency, without the need for additional input. The potential additional output at country A is not reflected in its efficiency measure because the additional output does not apply across all output dimensions. Table 8 illustrates the slack values identified in the next stage of the DEA analysis. The slack variables for 100% efficient countries are zero except for Slovak Republic. Therefore, Denmark, Finland, Ireland, Sweden, United Kingdom, Cyprus, Czech Republic, Latvia, Lithuania, Poland, Romania, and Turkey are Pareto-efficient as the DEA model has been unable to identify some feasible production point which can improve on some other input or output level. However, for Slovak Republic exchange rate stability, international liquidity, and real GDP growth are on efficiency frontier, but current account as percentage of exports, current account as percentage of GDP, and GDP per head of population have excess values by 2.74 (units), .69 (units), and 10315.5 (units) respectively. On the other hand, for Austria, besides increasing the output level of current account as percentage of exports, there is further scope for increasing current account as percentage of exports by 4.45 (units), exchange rate stability by .13 (units), current account as percentage of GDP by 2.34 (units), international liquidity by 3.71 (units), and real GDP growth by .71(units). Austria can follow Ireland and Denmark as its role model and emulate their policies. Similarly, Belgium can reduce its inflation level by .75 units, and increase current account as percentage of exports by 2.72 units, exchange rate stability by 2.30 units, International liquidity by 4.98 units and real GDP growth by.34 units, while maintaining efficient levels equivalent to that of its peers—Denmark and Sweden. On the same lines, France can increase its output factors, current account as percentage of exports by 6.01, exchange rate stability by 2.86 units, current account as percentage of GDP by 2.89, International liquidity by 3.05 units and real GDP growth by.52 units to follow in the footsteps of its peers—Denmark and Ireland. Similarly, we can find the slack factors for Slovenia, Bulgaria, Germany, Netherlands, Croatia, Greece, Malta, Estonia, Hungary, Spain, Italy, and Portugal. Table 8 illustrates the slack values of the relevant factors for inefficient countries.

Table 9 & 10 illustrate the CRS efficiency, VRS efficieny, scale efficiency, and returns to scale for the 28 EU nations. With the exception of United Kingdom, Ireland, Denmark, Czech Republic, Lithuania, Poland, Turkey, and Finland, all other countries exhibit decreasing returns to scale. Therefore, for Austria, Belgium, France, Germany, Greece, Italy, Netherlands, Portugal, Spain, Sweden, Bulgaria, Croatia, Cyprus, Estonia, Hungary, Latvia, Malta, Romania, Slovak Republic, and Slovenia further maximizing the output variables is hampered by inflation. The scale efficiencies tend to be quite low (less than or equal to 70%) for Belgium, Germany, Greece, Italy, Spain, Portugal, Estonia, Hungary, Bulgaria, Latvia, Malta, Romania, Slovak Republic, and Slovenia. These countries should model themselves (in terms of the economic indicators) comparable to their closest best peer. As these nations display decreasing returns to scale, this implies that there is considerable scope for improvement by improving the economic factors as reflected by their best peer countries. Figure 3 illustrates all the efficiencies for the participating EU nations.

5. Summary And Conclusions

This study uses Data Envelopment Analysis approach (DEA) to compare the relative performance of the 28 EU nations using seven economic variables. The DEA methodology benchmarks best-performing nations against worst-performing nations. This study investigates the effectiveness of EU in delivering growth to the member nations especially with many members joining the union quite recently. This study evaluates if the union succeeded in its goal of creating uniform conditions in terms of lower inflation, monetary policy coordination, lower budgetary deficits, and lower currency volatility by introducing single currency and coordinating monetary policy. The analysis of the economic data of the participating EU nations from 1999 to 2006 enables us to study the variation in the performance of individual EU nations over a seven-year time-period under the union. This study illustrates that economic integration enabled European Union nations to have converging economic performance in the beginning, but after five years many nations started lagging behind. As illustrated in the empirical analysis, in the year 1999, at the beginning of the economic integration, thirteen out of twenty eight member nations have 100 percent efficiency. On the other hand, in the year 2002, seventeen out of twenty eight nations had a hundred percent efficiency rate. After years 2002-4, more and more nations started lagging behind. In January 2006, only thirteen nations are 100 percent efficient, while all other nations are lagging behind in economic performance. This study also illustrates the possibility of achieving higher level of economic performance through slack analysis. The slack analysis indicates that the inefficient nations should make policy changes to manage inflation and improve economic parameters. The study also shows the areas in which inefficient member nations are lagging behind and how they can improve their performance to bring them at par with other participating nations.

We used data envelopment analysis to benchmark EU 28 nations. The data envelopment analysis is a powerful technique for performance measurement. DEA is a multifactor productivity analysis model for measuring the relative efficiencies of a homogenous set of decision-making units. The major strength of DEA is its objectivity. DEA identifies efficiency ratings based on numeric data as opposed to subjective human judgment and opinion. In addition, DEA can handle multiple input and outputs measured in different units. Also, unlike statistical methods of performance analysis, DEA is non-parametric, and does not assume a functional form relating inputs and outputs.

However, as with any other study, this study using DEA has certain limitations (Ramanathan, 2003). The application of DEA involves solving a separate linear program for each DMU. Thus, the use of DEA can be computationally intensive. In addition, as DMU is an extreme point technique, errors in measurement can cause significant problems. DEA efficiencies are very sensitive to even small errors, thus making sensitivity analysis an important component of post-DEA procedure. Also, as DEA is a non-parametric technique, statistical hypothesis tests are difficult to apply. Therefore, further extension of this study would be to perform principal component analysis of the all the DEA model combinations. Furthermore, we can also use logistic regression to test the validity of the results.

6. References, Figures, and Tables available upon request from the contact author.