**T.C.**
**BAHÇEŞEHİR ÜNİVERSİTESİ**

# DETERMINING THE RELATIVE EFFICIENCY OF THE STOCK MARKETS BY CLASSICAL AND FUZZY DATA ENVELOPMENT ANALYSIS

**M.S. Thesis**

**Hakan BALKAN**

**İstanbul, 2011**

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**Supervisor: Assoc. Prof. Dr. F. Tunç BOZBURA**
**Co-Supervisor: Asst. Prof. Dr. Ahmet BEŞKESE**

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Acting Director

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Examining Committee Members:

Assoc. Prof. Dr. F. Tunç BOZBURA (Supervisor) :

Prof. Dr. Selim ZAİM :

Assoc. Prof. Dr. Erkan BAYRAKTAR :

## ABSTRACT

DETERMINING THE RELATIVE EFFICIENCY OF THE STOCK MARKETS BY CLASSICAL AND FUZZY DATA ENVELOPMENT ANALYSIS

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In this study the efficiency of the stock markets of 45 countries is examined with a country-based approach by using classical and fuzzy Data Envelopment Analysis (DEA) methods. In the study, beside evaluation of the results of classical and fuzzy Data Envelopment Analysis, there is a detailed literature survey about the relationship between the stock markets and economic growth, the determinants of the stock market development and methodology.

The input variables in DEA models are Gross Domestic Product (GDP), GDP per capita, institutional environment, business environment, financial stability, banking financial services and non-banking financial services. The outputs variables are market capitalization value in billion USD, value traded in billion USD and turnover ratio.

Classical DEA models were solved for years 2007, 2008 and 2009. In classical DEA application in addition to overall efficiency (CCR), pure technical efficiency (BCC) and scale efficiency scores; target values and reference tables for these years were presented. The change in efficiency over years was measured by using Malmquist Total Productivity Index.

In fuzzy DEA application, the efficiency scores for three α-cut levels (0.25, 0.50, and 0.75) obtained by using Wang et al. (2005) approach were given and then countries were ranked by using Minimax Regret Approach. Finally comparison of efficiency scores obtained by classical and fuzzy DEA were presented.



**Keywords:** Stock Market, Data Envelopment Analysis, Fuzzy, Efficiency

# ÖZET


HİSSE SENEDİ PİYASALARININ ETKİNLİĞİNİN KLASİK VE BULANIK VERİ ZARFLAMA ANALİZİ İLE BELİRLENMESİ

Balkan, Hakan

Endüstri Mühendisliği
Tez Danışmanı: Doç. Dr. F. Tunç BOZBURA

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Bu çalışmada 45 ülkenin hisse senedi piyasalarının etkinliği ülke bazlı bir yaklaşımla ve klasik ve bulanık Veri Zarflama Analizi (VZA) yöntemleri kullanılarak incelenmeye çalışılmıştır. Çalışmada, klasik ve bulanık Veri Zarflama Analizi sonuçlarının değerlendirilmesi yanında hisse senedi piyasaları ve ekonomik büyüme, hisse senedi piyasalarının gelişmişliğini etkileyen faktörler ve metodoloji hakkında detaylı bir literatür araştırması bulunmaktadır.

VZA modellerinde girdi değişkenleri Gayri Safi Yurtiçi Hasıla, kişi başı Gayri Safi Yurtiçi Hasıla, kurumsal çevre, iş çevresi, finansal istikrar, bankacılık hizmetleri ve bankacılık dışı finansal hizmetlerdir. Çıktı değişkenleri ise milyar USD cinsinden piyasa kapitalizasyonu, milyar USD cinsinden işlem hacmi ve devir oranıdır.

Klasik VZA modelleri 2007, 2008 ve 2009 yılları için çözülmüştür. Klasik VZA uygulamasında toplam etkinlik (CCR), saf teknik etkinlik (BCC) ve ölçek etkinliği değerlerine ek olarak ilgili yıllar için hedef değerler ve referans tabloları sunulmuştur. Etkinliğin yıllar içindeki değişimi Malmquist Toplam Prodüktivite Endeksi ile ölçülmüştür.

Bulanık VZA uygulamasında Wang ve diğ. (2005) yaklaşımı kullanılarak üç α-kesim düzeyi (0.25, 0.50, and 0.75) için elde edilen etkinlik değerleri verilmiştir ve sonrasında ülkeler Minimax Pişmanlık Yaklaşımı kullanılarak sıralanmıştır. Son olarak klasik ve bulanık VZA yöntemleri ile elde edilen etkinlik değerlerinin karşılaştırması sunulmuştur.



**Anahtar Kelimeler:** Hisse Senedi Piyasası, Veri Zarflama Analizi, Bulanık, Etkinlik

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# ABBREVIATIONS

| | | |
|---|---|---|
| **Banker Chames Cooper** | **:** | **BCC** |
| **Chames Cooper Rhodes** | **:** | **CCR** |
| **Change in Efficiency** | **:** | **CE** |
| **Change in Technical Efficiency** | **:** | **CTE** |
| **Constant Returns to Scale** | **:** | **CRS** |
| **Data Envelopment Analysis** | **:** | **DEA** |
| **Decision Making Unit** | **:** | **DMU** |
| **Decreasing Returns to Scale** | **:** | **DRS** |
| **Fuzzy Data Envelopment Analysis** | **:** | **FDEA** |
| **Gross Domestic Product** | **:** | **GDP** |
| **Increasing Returns to Scale** | **:** | **IRS** |
| **Istanbul Stock Exchange** | **:** | **ISE** |
| **Linear Programming** | **:** | **LP** |
| **Minimax Regret Approach** | **:** | **MRA** |
| **Organisation for Economic Co-operation and Development** | **:** | **OECD** |
| **Total Factor Productivity** | **:** | **TFP** |
| **United States Dollar** | **:** | **USD** |

# 1. INTRODUCTION

Financial market is a broad term describing any marketplace where buyers and sellers participate in the trade of assets such as equities, bonds, currencies and derivatives. Financial markets are typically defined by having transparent pricing, basic regulations on trading, costs and fees and market forces determining the prices of securities that trade. Financial markets are divided into two: money markets and capital markets. Money markets fund short-term supply and demand whereas capital markets fund medium or long-term supply and demand. While the most important actors in the money markets are banks, this is stock exchanges in capital markets. The most important and common tools traded on stock markets are shares are and bonds.

When it is considered that value traded in 2009 in the world was about 80 trillion USD while total GDP of the world in 2009 was about 56 trillion USD, the importance of the stock markets can be understood easily. Every country in the world aims to get bigger shares in these markets.

Some reasons why a stock market is an important financial institution and produces huge amount of trading volume can be stated as follows (Rousseau and Wachtel, 2000, p.1936-1937):

- A stock market provides investors and entrepreneurs with a potential exit mechanism especially for venture capital investments.
- Foreign direct investment and portfolio investments enter into especially emerging market and transition economies through stock markets.
- The provision of liquidity through organized exchanges encourages both international and domestic investors to transfer their surpluses from short-term assets to the long-term capital market, where the funds can provide access to permanent capital for firms to finance large, indivisible projects that enjoy substantive scale economies
- Since stock market provides important information, shareholders can benefit from this, managers become more careful about their decisions and benchmarking will be easier between companies.

There are a lot of studies which support the view that stock market positively contribute to economic growth and other benefits of stock markets. However, there are some negative approaches or reservations about stock markets. For instance Singh (1997) claims that the actual operation of the pricing and takeover mechanism even in well functioning stock markets lead to short termism and lower rates of long term investment particularly in firm specific human capital and because of this short termism managers are rewarded for their success in financial engineering instead of for creating new wealth through organic growth. Additionally, Singh (1971) argues that the takeover mechanism focuses on the basis of size rather than performance so a large inefficient firm gets a higher chance of survival than a small relatively efficient firm. Bhide (1994) argues that selling shares easily in very liquid markets weaken commitment and incentive to exert corporate control of investors (Yartey, 2008, p.5).

As seen, positive aspects of stock markets emphasized in the literature. The subject of this study is to examine the efficiency of stock markets with a country-based approach by using classical and fuzzy Data Envelopment Analysis methods.

For this study, efficiency can be defined as the degree of realization of the stock market objectives defined for a country as a result of the activities realized for reaching these goals. The methods for measuring efficiency can be classified under three headings: the ratio analysis, parametric methods and non-parametric methods. In this study Data Envelopment Analysis (DEA) which is one of the non-parametric methods is used as a method for evaluating stock market efficiencies of countries.

Data Envelopment Analysis is a relatively new, linear programming based, data oriented approach which is directed to frontiers rather than central tendencies for evaluating the performance or efficiencies of a set of peer entities called Decision Making Units (DMUs) which convert multiple inputs into multiple outputs (Cooper, 2004, p.1-3).

DEA is decided as a proper method to examine stock market efficiencies of countries because it does not need to have specific functional forms of relations between inputs and outputs, a large number of inputs and outputs can be considered at the same time in DEA and the weights of inputs and outputs are determined by the model.

DEA is used in different areas to evaluate efficiency such as banking, health and education. However, during the literature survey, any internationally cited article is found which examines the efficiency of stock markets by using DEA method.

Two important stages in DEA models are to determine DMUs and inputs and outputs. In this study, 45 countries of which 25 are developed countries and 20 are developing countries taken as DMUs. The 45 countries represent 90 percent of whole world in terms of market capitalization value and 95 percent of the whole world in terms of trading volume. For inputs variables Gross Domestic Product (GDP), GDP per capita and the first five pillars of Financial Development Report of World Bank is used. The first five pillars are namely; institutional environment, business environment, financial stability, banking financial services and non-banking financial services. As outputs variables three market-related variables are used. These variables are, market capitalization value in billion USD which is the sum of product of stock price by stock number; value traded in billion USD which is the value of buying or selling through year and turnover ratio as percent, which division of the value traded to average (current year and the year before current year) market capitalization.

Classical DEA is employed in the study for three years: 2007, 2008 and 2009. The change in efficiency over years is measured by using Malmquist Total Productivity Index which measures total factor productivity change over time using distance functions.

Most of the data regarding inputs and outputs can be evaluated imprecise or vague especially the data take place in Financial Development Report. In Financial Development Report all pillars and sub pillars are weighted with a conservative approach and have equal weights. In order to include imprecise data into the model Fuzzy Data Envelopment Analysis (FDEA) is employed in the study as a type of classical DEA and the results of two methods are compared. The efficiency scores in FDEA are found and ranked by Wang, Greatbanks and Yang (2005) approach.

This research has three sections following introduction:

In the second section there is a detailed literature survey about the relationship between the stock markets and economic growth and the determinants of the stock market development giving both theoretical and empirical dimensions. Also in the same section a detailed information about efficiency, Data Envelopment Analysis, Data Envelopment Analysis models, Malmquist Total Productivity Index and Fuzzy Data Envelopment Analysis.

The third section is the application section and includes stages of application, efficiency scores obtained by using classical DEA for years 2007, 2008 and 2009, target values and reference tables for these years, results of Malmquist Total Productivity Index, efficiency scores obtained by using fuzzy DEA, ranks of countries in terms of loss of efficiency by using Minimax Regret Approach and finally comparison of efficiency scores obtained by classical and fuzzy DEA.

In the last section the results reached in the study is summarized and some recommendations are presented for the further research and decision makers.

# 2. LITERATURE SURVEY

## 2.1 THE STOCK MARKETS AND ECONOMIC GROWTH

### 2.1.1 Financial Development and Economic Growth in General

There are a lot of academic researches on financial development and economic growth in the literature. Some of those researches include both banking sector and stock markets in their analyses. Some of them on the other hand, include either banking sector or stock markets in their works. In recent years, it is observed that the number of academic studies on relationship between development of stock markets and economic growth has increased.

There are five explanations for the causal relationship between financial development and reel sector backed economic growth (Blum 2002, p.6). These explanations will be mentioned below.

(a) No causal relationship: Any of the scholars on development economics, including Nobel Prize winners, do not see finance as a focus of research on development economics (Meir and Seers 1984). In addition, according to the neo-classics, who focus on external technological developments and growth in population, savings is not a determining element of long term economic growth. They also claim that financial intermediaries have not an effect on the increase in long term economic growth (Levine 1997, p. 688).

(b) Demand-following relationship: According to the Robinson (1952), financial development follows the development in the reel sector. As a result, demand for the financial services is formed. Lucas (1998) on the other hand, claims that the role of the development of financial sector on the economic growth is exaggerated unnecessarily (Deb and Mukherjee 2008, p. 143).

(c) Supply-leading relationship: Development of financial services provides development of reel sector. Gurley and Shaw (1955), Goldsmtih (1969), Mckinnon (1973), Levine and Zarvos (1998) have made researches that supports this argument.

(d) Financial development affects economic development negatively: In the post-Keynesian approach financial liberalization causes risky investment implementations, weak financial structures, and low reel sector growth rates. It also introduces opportunities for inefficient direct rent seeking facilities and it completely distorts growth (Grabel 1995, pp.127–130). New Keynesian theory (Stiglitz and Weiss, 1981), on the other hand, claims that market equilibrium can be neither a law nor a necessary assumption for competitive analysis in the financial markets (Auerbach and Siddiki 2004, p. 243).

(e) Reciprocal causality between financial development and economic growth: Financial markets develop as a result of economic growth. As a result, it contributes to the real economic growth with its feedback effect. Therefore, there can be mentioned a two sided relationship between development and economic growth rather than a one sided causal relationship. Patrick (1966) claims that real sector is an important element of development of financial sector in the economies of underdeveloped countries, whereas in developed countries finance fits more and more to do Demand-following approach (Blum 2002, p. 7). Lewis (1955), Greenwood and Jovanovic (1990), Berthelemy and Varoudakis (1996), Greenwood and Smith (1997) have made studies that supports this argument.

Scholars that support supply-leading approach emphasize that functions that were provided during the economic growth process and financial liberalization have positive effects on economic growth. On the other hand, scholars that support demand-following approach claims that financial system can be developed as a result of economic growth.

Studies that support supply-leading approach constitute the majority in the Literature. Pioneer studies that deal with financial development and economic growth with supply-leading approach are Schumpeter (1912), Gurley and Shaw (1955), and Goldsmith (1969).

Joseph Schumpeter (1912) claims that services like mobilization of savings, evaluation of projects, management of risk, monitoring of managers, and facilitation of operations, which are provided by financial intermediaries, forms foundation for technological innovation and economic growth (King and Levine 1993, p. 717).

One of the most comprehensive studies that analyses the channels by which financial development effects economic growth was made by Pagano (1993). Pagano examines both the direction of causal relationship between financial development and economic growth and the way that financial development affect economic growth (whether increasing investment efficiency or investment rate). Pagano (1993) claims financial intermediaries can affect economic growth by effecting social marginal efficiency of capital, transfer rate of savings to investments, and private saving rate (Pagano 1993, pp. 614–615).

According to the Pagano (1993), during the process of transformation of savings to investments, the effect of financial development on economic growth will increase even more in case of a reduction on transaction costs, commissions and fees that banks and the stock markets demand (p.615). Financial intermediaries, increase economic growth through increasing productivity of capital by way of promoting investment of more risky but more productive investment projects by their ability on information gathering and risk sharing (p.615). Development of capital markets may affect the saving rate which can affect economic growth. Risk sharing, household loans and interest rate affect rate of saving. As a result of risk sharing that is provided by financial intermediaries, decrease in saving rates has a negative impact upon economic growth (p. 617). Liquidity constraints increase saving rates in case consumption is made by current sources. The increase in the total saving rates transforms to a more rapid growth. In contrast, increase in credits on consumption or mortgages causes a decrease both in savings and the growth (pp. 617-618). Financial pressure and imperfect competition markets cause the interest rates that paid to people whose marginal propensity to consume is high to be lower than the normal interest rates that is expected. In this case, there will be a depreciation of marginal product of capital (pp. 618–619).

### 2.1.2 The Stock Market Development and Economic Growth

It is widely accepted that financial development is closely related with economic growth. Especially for developing countries, there are a lot of studies on the relation between stock market development and economic growth.

Throughout the last twenty years, majority of the academic studies claim a positive relation between stock market development and economic growth. [Levine (1991,1997), Atje and Jovanovic (1993), Devereux and Smith (1994), Obstfeld (1994), Demirgüç-Kunt and Levine (1995), Bencivenga et al. (1996), Levine and Zervos (1993, 1995, 1998), Singh (1997), Rousseau and Wachtel (2000), Khan and Senhadji (2000), Arestis et al (2001), Van Nieuwerburgh (1998, 2005), Beck and Levine (2003), Rousseau and Sylla (2003), Beck and Levine (2004)]. In the following paragraphs of this section it will be tried to explain significant academic studies on the relation between stock market development and economic growth.

Atje and Jovanovic (1993) used the ratio of value traded to GDP for stock market in their cross-section analysis in which they used ordinary least squares. They also used real growth per capita as the indicator for economic growth. In their study, they examined 40 countries over the period 1980-1988. Their results indicate that there is a strong relationship between economic growth and the stock market development (Atje and Jovanovic 1993, pp. 632–640).

Levine and Zervos (1998) examined 47 countries for the period between 1976 and 1993. They used the ratio of market capitalization to GDP as the indicator of the stock market development. They also used turnover ratio (trading volume to average market value) as the liquidity indicator. They examined increase in economic growth (real GDP per capita), capital accumulation, efficiency (economic growth-0.3xcapital accumulation), and saving rates (private savings in terms of GDP in percentage) by the indicators related to stock market. In addition, they used variables related to integration of international financial markets and volatility in stock markets. As a result, they found a significant relation between liquidity indicators in stock markets and economic growth, capital accumulation, and increase in efficiency. However, they could not find a direct relationship between variables mentioned above and market value and volatility. Another finding of their study is banking sector and stock markets are not substitutes but complementary (Levine and Zervos 1998, pp. 537–558).

Due to the problems on econometrics methods in the study of Levine and Zervos (1998), Beck and Levine (2004) made another attempt to examine the same subject by

using panel data sets and generalized moments method developed for dynamic panels with similar indicators over the period 1976-1998 for 40 countries.

Beck and Levine (2004) did not use value traded because according to them value traded does not accurately measure market liquidity and if markets are on the rise value traded forecasts economic growth higher as a result of rising stock prices. They also eliminate market capitalization because of the fact that the relationship between market capitalization and economic growth is not significant. Instead they used turnover ratio as an indicator of stock market development. As the indicator of economic growth, they used real GDP per capita. In conclusion they found that the hypothesis that there is no relationship between financial development and economic growth is null. Both banking sector and stock markets have a positive impact upon economic growth. In addition, they put forward stock markets provides different services than banks and stock markets support economic growth independent from banking sector (Beck and Levine 2004, pp. 427–440).

Arestis et al. (2001) used quarterly data of 5 countries in their advanced time series techniques. They used the ratio of market capitalization to GDP as a stock market development indicator. They also used real GDP as an economic growth indicator. According to the analysis results, stock market development has a positive impact upon economic growth but the significance of banking sector is less than the stock markets (Arestis et al 2001, pp. 24–37).

Kulatrane (2001) examined the effect of financial deepening on the long run economic growth for a period of 38 years (1954-1992) in South Africa. He used value traded as an indicator of stock market development level and real GDP per capita as an indicator of economic growth. He also included interest rate, investment rate, and human capital as other indicators in his study. He developed two models by using VECM Structure. In MODEL I, he searched that whether financial system effects real GDP per capita directly or indirectly through investment rate or not. In MODEL II on the other hand, he made the same analysis by considering possible feedback effects. Model results indicate that financial deepening strengthens economic growth in South Africa but this occurs indirectly by saving rates. In addition, in MODEL II he also concluded that stock

markets have a more significant effect on real GDP per capita (Kulatrane 2001, pp. 3–25).

Rousseau and Wachtel (2000) used both cross-section and generalized moments dynamic panel data methods for 47 countries over the period of 15 years between 1980 and 1995. In cross-section model, they used the ratio of market capialization to GDP and value traded as the indicators of stock market development. In panel data model on the other hand they used market capitalizatiıon and value traded. As for the economic growth indicator they used real GDP. According to the croos-section model results, stock market development has a positive impact on economic growth in accordance with supply-leading approach. Results of panel data method indicate that both market capitalization and value traded effects economic growth positively nevertheless effect of value traded is greater and more permanent. In conclusion, market liquidity has very significant effect on economic growth (Rousseau and Wachtel 2000, pp.1938–1956).

Rajan and Zingales (1998) examined 41 countries for the period 1980-1990 whether industrial sectors that are relatively more in need of external finance develop disproportionately faster in countries with more-developed financial markets. They used the ratio of annual average real growth rate to the value added in industry and, net investments as indicators of growth rate of industries. They also used the ratio of stock market capitalization to the GDP and current accounting standards as financial development indicators. The results of their studies show that financial development, in firms that are intensely in need of external finance, reduce cost of external finance and have a positive impact upon economic growth and also it plays a significant role in emergence of new firms (Rajan and Zingales 1998, pp. 559–586).

Beck et al. (2008) studied growth rates of different industries by considering financial development levels of countries. They examined 36 industries from production sectors of 44 countries. For development they used private sector credit data as an indicator. The results indicate that the industries which are formed heavily by small firms, develops disproportionately in the countries that have developed financial systems. Small firms in financially developed countries have greater share in the total value added produced in the whole economy in comparison to the small firms of a financially less developed country. Therefore financial development causes a disproportionate

development of small firms and also it increases value added that firms produced. According to the authors, this study is a complimentary to those of Guiso, Sapienza and Zingales (2004); Cetorelli and Strahan (2006); Kumar, Rajan and Zingales (2001). Additionally, Beck et al (2008) used stock market turnover ratio and value traded as an indicator of financial development in their alternative model. In this model, it is shown that small firms progress more rapidly in the countries with developed financial systems.

Yeniel (2009) examined the effects of banking sector and stock market development on economic growth in the 29 countries that are whether EU member or candidates, over the period 1993-2007. In their study they used static and dynamic panel data analyses, panel co-integration analysis, and causality analyses. According to the static regression results, in developing countries, development of banking sector is more significant on economic growth than the developed countries whereas in developed countries development of stock markets is more influential on economic growth. According to the results of the dynamic regression model development of stock markets is more significant in both developing and developed countries. In addition, it was pointed out that these relations are also valid in the long run (Yeniel, 2009).

In the literature, there are also researches on single countries rather than a group of countries on the relationship between stock markets and economic growth.

Nowbutsin and Odit (2009) examined the effects of stock market development on economic growth in both short and long run for Mauritius over the period of 1989-2006. They used the ratio of market capitalization to GDP and value traded to GDP as stock market development indicator. They also used secondary enrollment ratio and the ratio of foreign direct investments to GDP as indicators of economic growth. They concluded that development of stock markets have a positive effect on the economic growth both in the long run and short run (Nowbutsin and Odit 2009, pp. 77-88).

Van Nieuwerburg et al (2006) examined the effects of financial development on economic growth in Belgium for 4 different periods (1830-2002) based on their distinctive characteristics. They used co-integration and Granger causality tests. They mainly used data based on banking sector along with data on market capitalization as an

indicator for stock markets. They claimed that financial development and financing that are based on stock markets are significant determinants on economic growth.

The reasons for contribution of stock markets on economic growth, along with the increase of liquidity in trade in the post 1873 era, are removal of regulative barriers to companies with limited liability and removal of barriers to trading of shares of companies that are listed in the stock exchanges. Additionally, stock market development is a better forecaster of economic growth than bank-based development (Van Nieuwerburg et al 2006, pp. 13-38).

Hossain and Kamal (2010), examined the existence of a causal relationship and cointegration between stock markets and economic growth in Bangladesh for a period of 1976-2008. In the study, they used the ratio of market capitalization to GDP as an indicator of stock market development. They also used real GDP per capita and real GDP growth rate as indicators of economic growth. As a result, they claimed that stock market development and economic growth have the similar stochastic trend thus they have mutual dependence. Direction of the causality is from stock market development to the economic growth. As for the Bangladesh economy, they found out that stock market development affects economic growth significantly (Hossain and Kamal 2010, pp. 87-95).

Ake and Ognaligu (2010) examined the relationship between stock markets and economic growth in Cameroon over the period 2006-2010. They used Granger based Sims causality test in their study. Researchers used real GDP per capita as indicator of the economic growth. They also used the ratio of market capitalization to GDP, the ratio of value traded to GDP, and turnover ratio as indicators of stock market development. According to the results, contrary to the all other results in the literature, stock markets in Cameroon do not affect the economic growth (Ake and Ognaligu 2010, pp. 82-88).

Deb and Mukherjee (2008) examined the relationship between stock market development and economic growth by using unit root and long run Granger non-causality tests in India over the period 1996-2007. They used growth in the real GDP per capita as indicator of economic growth. They also used the ratio of market capitalization to the real GDP and the ratio of total value traded to real GDP as the

indicators of development level of stock markets in the country. They concluded, in accordance with supply-leading approach, that there is a causal relationship from stock market to economic growth in case real value traded and volatility are taken into account. In addition, they found out that there is a reciprocal relationship between economic growth and real market capitalization (Deb and Mukherjee 2008, pp. 142-149).

Dritsaki and Dritsaki-Bargiota (2005), examined the causal relationships between stock markets, banking sector, and economic growth in Greece for the period of 1988-2002. They used market capitalization as the indicator of stock market development. They also used money supply as the banking indicator and the industrial production as the indicator of economic growth. According to the results, there is a reciprocal relationship between banking sector and economic growth. The way of the relation is from economic growth to stock markets as indicated in the demand-following approach. Furthermore, they could not find a causal relationship between banking sector and stock markets (Dritsaki and Dritsaki-Bargiota 2005, pp. 113-127).

Athanasios and Antonios (2010) used Vector Error Correction model and co-integration tests in their research to find out causal relationship between stock markets, credit markets, and economic growth both in the long run and in the short run. They used growth rate of real GDP as the indicator of economic growth; stock market general index as the stock market indicator; and the percentage of credits given to domestic private sector by banking sector to GDP as the credit markets indicator. In conclusion, they found out a one-side causal relation from economic growth towards stock markets in harmony with demand-following approach (Athanasios and Antonios 2010, p. 33-42).

Müslümov and Aras (2002), examined the relationship between economic growth and stock markets for 22 OECD countries including Turkey over the period 1982-2000. They used panel data method and Granger causality tests. Müslümov and Aras used real GDP per capita as the indicator of economic growth; and they also used the ratio of market capitalization to GDP and the ratio of value traded to GDP as the indicators of stock market development. In some countries such as Turkey, Austria, Denmark, Germany, Italy, Luxembourg, Mexico, and Norway, they could not find any causal

relationship between stock markets and economic growth. In other countries such as Canada, Finland, Spain, and Sweden, they found out a one-sided causal relationship (as in the supply-leading approach) materialized by market capitalization. According to the research results, direction of causal relationship between stock market development and economic growth does not change both in the short run and in the long run (Müslümov and Aras 2002, pp. 90-100).

### 2.1.3 The Stock Market Development and Economic Growth in Turkey

Ağır (2003), examines the effects of variables which are related to the banking and stock markets on economic growth using econometrics methods such as the unit root test, cointegration analysis and the three-month data for the period 1987-2002. He concludes that for examined period, ISE has a positive contribution to economic growth and the relationship between banking and the ISE is weak.

Yücel (2009), examines the effect of capital market development on economic growth in Turkey using the monthly data for the period of 1997-2007 and principal component analysis, unit root tests and cointegration tests methods. In the study as indicators of sophistication of capital market; international integration (stock index investments to ISE index), trading volume of Istanbul Stock Exchange to GDP, the total traded value of ISE to ISE index and ISE index, as an indicator of economic growth the real GDP per capita are taken. As a result, it is concluded that there is a long-term positive relationship between the development of capital markets and economic growth.

Gokdeniz, Erdogan and Kalyüncü (2003), using quarterly data for the period 1989-2002 and the Least Squares method find that the stock market in Turkey does not support economic growth, private bonds do not have explanatory power on growth, the increase in the rate of the total commercial bank assets does not support economic growth. Additionally they find money explains growth and inflation has a negative effect on growth.

Karagöz and Armutlu (2007), examined the relationship between stock market development and economic in Turkey using quarterly data for GDP and SE-100 for the period 1988-2006. In their research which is using Granger causality test, they finds

economic growth is the reason of the development in stock market, whereas the stock market development does not have an impact on economic growth.

Kar and Pentecost (2000), examined the relationship between Turkey's banking sector development and economic growth and the direction of causality for the period 1963-1995 using cointegration and Granger causality tests. In the study, money to income ratio, bank deposit liabilities to income ratio, private sector credits to income ratio, ratio of the domestic private sector credits in loans and domestic loans to income has been taken as development indicators of the banking sector and GDP has been taken as theindicator of economic growth. As a result a causal relationship has been identified between financial development and economic growth in the long term. However, there is not a absolute decision about the direction of causality, considering the results obtained in the studied period, it is concluded that in line with demand-following approach there is a causal relationship from economic growth to financial development in Turkey.

## 2.2 THE DETERMINANTS OF THE STOCK MARKET DEVELOPMENT

### 2.2.1 The Determinants of The Stock Market Development

When the studies that are investigating the determinants affecting the development of the stock markets are examined, the author of this thesis can state that they can be classified in two main subtitles: (1) Macroeconomic Factors (2) Institutional / Structural Factors.

Macroeconomic factors are income level, growth rate, investment rate, savings rate, inflation, foreign investment, macroeconomic stability, currency stability and similar factors.

Structural / Institutional factors can be divided into three in their own.

(a) Legal Structure and Institutions: These factors related to the legal structure and the applications such that property rights, shareholder protection, legal origin (French, English, German and so on), strengths of legal rights, accounting standards, disclosure

policies, sanctions and regulations, transparency, the efficiency of the courts, contract enforcement and similar factors.

(b) Financial and Economical Structure: These factors are liberalization, trade openness, the dominant character of the financial system (banking based or market based), banking and insurance sectors, cost of doing business, human capital, remittances and similar factors.

(c) Administrative Structure and Risk: These factors are corruption, bureaucratic quality, the effective applicability of regulations, accountability, the level of intervention in the economy, willingness to delegate, political rights and political risks.

The results obtained from empirical studies (some of them will be explained in detail in next section) on the factors affecting development of the stock markets can be summarized according to factors as follows:

**Macroeconomic Factors**: In general, although there are the different opinions about the direction of causality, there is a strong and positive relationship between macroeconomic factors such as income level, growth rate, investment rate, savings rate, foreign investment, macroeconomic stability and the stock market development (Yartey 2008; Naceur et al. 2007; Garcia and Liu 1999; Wassal and Kamal 2005).

**Legal Structure and Institutions**: Generally, the countries has developed stock markets when they have advances in the level of protection of property rights, the level of shareholder protection, accounting standards, disclosure policies and sanctions, the effectiveness of the courts, and similar factors is more advanced countries with more developed stock market. The listed factors above are associated with both the level of development of the countries and legal origin of the countries. Common (English) law countries are more suitable for development of the specified factors and thus the stock markets rather than Civil (Roman) law countries (Buchanan and English 2007; La Porta et al. 1998; Demirgüç-Kunt and Levine 1999).

**Financial and Economical Structure:** There is a positive relationship stock markets and banking and non-banking financial sectors although according to the different stages of development the nature and direction may vary, also they are complementary

and not competing with each other (Yartey 2008; Naceur et al. 2007; Demirgüç-Kunt and Levine 1995; Garcia and Liu 1999). When the countries are categorized as market-based and bank-based, it is seen that the stock markets are more developed in more developed and common-law origin countries and the banking sector is more developed in civil-law origin countries. (Ergüngör 2004; Demirgüç-Kunt and Levine 1999). In addition, financial openness and liberalization in general positively affect the development of stocks markets (Levine and Zervos 1998; Wassal and Kamal 2005; Chinn and Ito 2006).

**Administrative Structure and Risk**: Although there are different findings about the degree of influence, the factors related to the administrative structure and risk such as the level of corruption, bureaucratic quality, the effective applicability of regulations, accountability, the level of intervention in the economy, political rights and political risks usually have a strong influence on the stock market development (Lombardo and Pagano 2000; Yartey 2008; Billmeier and Massa 2008).

### 2.2.2 Empirical Studies

In this part, empirical studies related to the determinants of the stock market development will be explained in detail.

Yartey (2008) examined the macroeconomic and institutional determinants of stock market development in emerging economies using a panel dataset of 42 countries for the period 1990 to 2004. The dependent variable in study the level of Stock Market Development measured by the value of listed shares divided by GDP, the explanatory variables and their measures used in the study are as follows:

- Income Level: Log GDP per capita in US dollars
- Banking Sector Development: The value of domestic credit provided by the banking system to the private sector relative to GDP
- Savings and Investment: Gross domestic savings as percentage of GDP and gross domestic investments as a percentage of GDP
- Stock Market Liquidity: The value traded as a percentage of GDP.
- Macroeconomic Stability: Real interest rate and current inflation

- Private Capital Flows: Foreign direct investment as a percentage of GDP and net private capital flows as a percentage of GDP.
- Institutional Quality: A composite index of four components from the International Country Risk Guide used as a measure of institutional quality: law and order, bureaucratic quality, democratic accountability and corruption.

He found some important results:

- Income level, domestic investment, banking sector development, private capital flows, and stock market liquidity are important determinants of stock market development in emerging markets.
- At early stages of stock market development, the banking sector is a compliment to the stock market in financing investment but as they both develop, banks and the stock market begin to compete with each other.
- Institutional quality is important determinant of stock market development in emerging markets.
- The main factors explaining the development of the stock market in emerging market countries can also valid in South Africa.

Frost, Gordon and Hayes (2006) examined the relationship between stock exchange disclosure systems (rather than actual company disclosures) and market development at 50 of the member stock exchanges of the World Federation of Exchanges during 1997-1998. They computed market development as the mean of five variables standardized before aggregation. (1) stock market capitalization held by minorities deflated by gross domestic product, (2) number of listed domestic companies deflated by country population (3) number of newly listed domestic companies deflated by country population (4) annual number of transactions in equity shares deflated by year-end market capitalization and (5) annual adjusted domestic trading volume deflated by year-end market capitalization. They found that in addition to legal protections and institutions the strength of the disclosure system that is disclosure rules, monitoring, and enforcement is positively associated with market development, after controlling for legal system, legal protection of investors, market size. Thus it can be concluded that the disclosure system is critical for development of the stock markets.

Naceur et al. (2007) examined the main macroeconomic determinants of stock market development and the impact of financial intermediary development on stock market capitalization using a sample of twelve MENA region countries over a varying period. The countries in the study are Bahrain, Egypt, Iran, Jordan, Kuwait, Lebanon, Morocco, Oman, Qatar, Saudi Arabia and Tunisia. They found that saving rate, financial intermediary (measured by credit to private sector), stock market liquidity (measured by the ratio of value traded to GDP) and the stabilization variable (measured by inflation change) are the important determinants of stock market development. Other findings of the study are income and investment are not significantly important for stock market development and banking sectors and stock markets are complements rather than substitutes in the growth process.

Billmeier and Massa (2009) examined the relation between the stock market capitalization and the determinants of stock market capitalization in a panel of 17 emerging markets in the Middle East and Central Asia, including both hydrocarbon-rich countries and economies without sizeable natural resource wealth. They included additional variables to their study: an institutional variable measured by the help of the "Economic Freedom Index" of Heritage Foundation and remittances. They found that both institutions and remittances have a positive and significant impact on market capitalization especially in countries without significant hydrocarbon sectors; whereas in resource-rich countries stock market capitalization is mainly driven by the oil price.

Levine and Zervos (1998) examined whether the indicators of stock market development change following the liberalization of specific capital controls in 16 countries including Turkey. They took the ratio of market capitalization to Gross Domestic Product (GDP), the ratio of total value traded to GDP, the ratio of total value traded to market capitalization (turnover ratio), and the volatility of stock returns as indicators of stock market development. They used the International Capital Asset Pricing Model (ICAPM) and the International Arbitrage Pricing Model (IAPM) to compute monthly measures and then analyzed the time-series behavior of these integration measures before and after policy changes in the liberalization of specific capital controls.

They found that stock markets tend to become larger, more liquid, and more volatile following the liberalization of restrictions on international portfolio flows and 10 out of 16 national markets exhibit significant signs of becoming more integrated internationally following the liberalization of investment and repatriation restrictions. They also examined the relationship between the indicators of stock market development and three regulatory indicators; the availability and quality of published information on listed firms, the level of accounting standards and the intensity of investor protection laws. They found that the results do not support the hypothesis that imposing internationally accepted accounting and investor protection rules will promote stock market development.

Wassal and Kamal (2005) investigated the relationship between stock market growth measured by the mean of the logarithm of market capitalization/GDP and trading value/GDP and economic growth, financial liberalization policies, foreign portfolio investment and country risk in 40 emerging economies between the period 1980–2000 over four distinct time periods: 1980–84; 1985–89; 1990–94; and 1995–99. They constructed their stock market development model in light of Calderon-Rossell's model and the previous discussion. They used Two Stages Least Squares combined with Fixed Effect technique.

The explanatory variables used in the study and their measures are as follows:
Economic growth: the logarithm of GNP per capita growth rate
Additional liquidity: the logarithm of the turnover ratio
Financial and economic policies: the number of listed companies, foreign direct investment to relative GDP, exports plus imports relative to GDP
Foreign portfolio investment: investment liabilities divided by GDP
Country risk: Political, financial and economic components of International Country Risk Guide.

By analyzing the results of the model they found that economic growth, financial liberalization policies, and foreign portfolio investments are the important factors for stock markets' growth compatible with demand-following approach and the political risk variable is not significant for stock market development.

Chinn and Ito (2006) investigated whether financial openness leads to financial (banking and stock markets) development after controlling for the level of legal development using a panel including 108 countries over the period 1980 to 2000. Their findings stated in the article are as follows:

- A higher level of financial openness contributes both directly and in an interactive manner with legal and institutional development to the development of equity markets but only if a country is equipped with a reasonable level of legal and institutional development
- A higher level of bureaucratic quality and law and order, as well as the lower levels of corruption, may enhance the effect of financial opening in fostering the development of equity markets.
- Among emerging market countries, the overall level of finance-related legal/institutional development increases stock market trading volumes and enhances the effect of financial openness. However, the finance related legal/institutional (level of creditor protection, effectiveness of the legal system in enforcing contracts, shareholder protection, the comprehensiveness of company reports) variables do not exhibit as strong an effect as the general legal/institutional variables( level of corruption, law and order, and the quality of the bureaucratic system)
- Liberalization in cross-border goods transactions is a precondition for capital account liberalization, the development in the banking sector is a precondition for equity market development and that the developments in these two types of financial markets have interactive effects.

Demirgüç-Kunt and Levine (1995), in their study examined the relationship between institutions of financial intermediation and stock markets for the period 1986-1993 in 41 countries. The main implication of their study is that the level of stock market development is highly correlated with the development of the banks, nonbanks, and insurance companies, and private pension funds. Other findings of their study are as follows:

- Big markets tend to be less volatile, more liquid and less concentrated in a few stocks

- Internationally integrated markets tend to be less volatile, and institutionally developed markets tend to be large and liquid.
- The three most developed markets are Japan, the United States, and Great Britain
- The most underdeveloped markets are Colombia, Venezuela, Nigeria, and Zimbabwe.
- Korea, Switzerland, and Malaysia have highly-developed stock markets,
- Turkey, Greece, Argentina, and Pakistan have underdeveloped markets.
- Some of emerging countries' markets such as Hong Kong, Singapore, Korea, Malaysia, and Thailand are more developed than some of developed countries' markets such as France, the Netherlands, Australia, Canada, Sweden, and Norway.

Garcia and Liu (1999) examined the macroeconomic determinants (real income, saving rate, financial intermediary development, stock market liquidity and macroeconomic stability) of stock market development in fifteen industrial and developing countries from 1980 to 1995. These countries include seven countries in Latin America, six countries in East Asia, and two industrial countries: the United States and Japan. The dependent variable in the study is market capitalization defined as the total market value of all listed shares divided by GDP. Explanatory variables and their measures are as follows:

Real income: real GDP in U.S. dollars
Income growth rate: Calculated by using real income
Financial intermediary development: Domestic credit to the private sector divided by GDP, the ratio of broad money supply M3 to GDP
Stock market liquidity: The ratio of total value traded to GDP, the ratio of the total value traded divided by market capitalization
Macroeconomic stability: Inflation rate, inflation change, the standard deviation of inflation rate

They found that the real income level, saving rate, financial intermediary development, and stock market liquidity are important determinants of market capitalization, while macroeconomic stability does not prove significant. They also found that stock market

development and financial intermediary development are complements instead of substitutes.

La Porta et al. (1998) is one of the pioneers who investigated effect of legal origins on finance. In their study "Law and Finance" they examined legal rules covering protection of corporate shareholders and creditors, the origin of these rules and the quality of their enforcement in 49 countries by classifying them according to origin of their commercial laws. The authors categorize the commercial laws as two broad traditions: common law which is English in origin and civil law which is Roman in origin. There are three major families in civil law with some differences: French, German and Scandinavian. They state in their study that in terms of legal protection and rights of shareholders and creditors common-law countries are the strongest, French-civil-law countries are the weakest. German-civil-law and Scandinavian countries fall between them. Also in terms of the quality of law enforcement German-civil-law and Scandinavian countries are the strongest and French-civil-law countries are the weakest, common-law countries come before French-civil-law countries. In addition they observe that the shares of largest public companies belong to limited number of investors in countries that fail to protect shareholders' rights.

La Porta et al. (2006) examined securities laws specially laws governing initial public offerings in 49 countries in relation with stock market development. They cite three alternative hypotheses in the literature and test them. The null hypothesis is to leave securities markets unregulated. Other two alternative hypotheses assume that regulation is necessary but differ in what kind of government intervention would be optimal within such a framework. They use 8 variables in their study: disclosure requirements, liability standards, supervisor characteristics, rule-making power, investigative power, orders, criminal sanctions, and public enforcement.

In conclusion, they states that the null hypothesis is invalid, that is, regulations are necessary because financial markets do not prosper when left to market forces alone and regulations facilitate private contracting rather than provide for public regulatory enforcement. They also point out that both extensive disclosure requirements and standards of liability facilitating investor recovery of losses are associated with larger stock markets. Finally, they states that legal origin predicts stock market development

for instance, common-law emphasis on private contracting and standardized disclosure and reliance on private dispute resolution using market-friendly standards of liability.

Buchanan and English (2007) investigated how legal foundation influences the return distribution, the growth rate of market capitalization, the ratio of market capitalization to gross domestic product (GDP) and the correlation structure of emerging market indices with developed market indices using a sample of 24 emerging markets over the period 1976-1999. They found that emerging markets from the French-civil law systems earned higher returns, have higher correlations with the world market portfolio, higher average growth rates in market capitalization and lower average market capitalization to GDP than their English common- law countries. Additionally, most emerging markets returns are more highly correlated to the returns of developed markets with an English common law tradition. They suggest in their study that market capitalization to GDP can be a better way to classify markets as emerging for the purposes of financial market research.

Demirgüç-Kunt and Levine (1999) examined cross-section of roughly 150 countries in order to analyze how the size, activity, and efficiency of financial systems differ across different per capita income groups, define different indicators of financial structure and identify different patterns as countries become richer, and investigate legal, regulatory, and policy determinants of financial structure after controlling for per capita GDP. They give the results of their study as follows (pp.4-5):

- Banks, other financial intermediaries, and stock markets all grow and become more active and efficient as countries become richer. As income grows, the financial sector develops.
- In higher income countries, stock markets become more active and efficient than banks. Thus, financial systems tend to be more market based.
- Countries with a common law tradition, strong protection for shareholder rights, good accounting standards, low levels of corruption, and no explicit deposit insurance tend to be more market-based, even after controlling for income.
- Countries with a French civil law tradition, poor accounting standards, heavily restricted banking systems, and high inflation generally tend to have underdeveloped financial systems, even after controlling for income.

Ergüngör (2004) finds interesting results somewhat similar to the results Demirgüç-Kunt and Levine (1999). In common-law countries which courts enforce laws effectively, providing them with more detailed creditor and shareholder protection laws has a greater impact on the development of financial markets compared with civil-law systems, both banking and stock markets tend to be more developed, whereas civil-law countries tend to be bank-oriented. In that stage one can think which structure is more preferable for economic growth. Levine (2002) studies this problem and finds that there is no doubt that overall financial development is related with economic growth but there is no empirical support for either the bank-based or the market-based view.

## 2.3 EFFICIENCY AND DATA ENVELOPMENT ANALYSIS

### 2.3.1 Efficiency and Related Concepts

The concepts efficiency, productivity and performance are often used instead of each other and they are related concepts but have different meanings.

Efficiency is the degree of realization of the objectives defined for an organization as a result of the activities realized for reaching these goals (National Productivity Center, Glossary of Productivity).

Performance is a general concept that includes efficiency, productivity, quality, innovation and profitability (Kecek 2010, p. 14). As seen the essential difference between performance and efficiency is that performance considers time and quality.

Productivity is a dimension of performance like efficiency and can be defined most generally as the value obtained by the ratio of goods or services produced to inputs to produce these goods or services (National Productivity Center, Glossary of Productivity). As seen the essential difference between productivity and efficiency is that productivity is usually based on only one input and one output and considers time.

### 2.3.2 Types of Efficiency

There are three types of efficiency: technical efficiency, scale efficiency and overall efficiency. They will be explained below.

#### 2.3.2.1 Technical Efficiency

Technical efficiency is the ratio of potential output to actual output (Candemir and Deliktaş 2006, p. 16). Technical efficiency can be classified as input oriented technical efficiency and output oriented technical efficiency (Lorcu 2008, pp. 39-40):

a) Input oriented technical efficiency: The success of a production unit in obtaining the current output level with the least possible use of resources.
b) Output oriented technical efficiency: The success of a production unit in producing the greatest possible output level using the proper combination of inputs.

#### 2.3.2.2 Scale Efficiency

There are three states in scale efficiency:

a) Constant Returns to Scale (CRS): If the rate of increase in inputs causes the same rate of increase in outputs that implies constant returns to scale.
b) Decreasing Returns to Scale (DRS): If the rate of increase in inputs causes the less than this rate of increase in outputs that implies decreasing returns to scale.
c) Increasing Returns to Scale (IRS): If the rate of increase in inputs causes the more than this rate of increase in outputs that implies increasing returns to scale.

#### 2.3.2.3 Overall Efficiency

Overall efficiency is multiplication of the scale efficiency and technical efficiency. For a DMU to be efficient it must be both technically efficient and scale efficient. If there is a difference between overall efficiency and scale efficiency this implies that related DMU is not scale efficient (Coeli 2005, p.172).

### 2.3.3 Measurement of Efficiency

The methods for measuring efficiency can be classified under three headings: the ratio analysis, parametric methods and non-parametric methods.

Ratio analysis is in the form of proportion with single input and single output to each other. Although due to ease of application and understanding it is a frequently used method, especially on systems contains more than one input and output may not be sufficient. To try merging more than one ratio in a single ratio reduce the intelligibility and cause subjective weighting.

Parametric methods use frontier approach in measuring efficiency and assume the presence the production function of the sector and structure of this function has an analytical basis. These methods generally use regression techniques for measuring efficiency and the production function is usually described by relating a single output to many inputs. In parametric methods, there are three approaches: Stochastic Frontier Approach, Distribution Free Approach and Thick Frontier Approach.

Non-parametric methods that emerged as an alternative to parametric methods has been adopted mathematical programming as solution technique. Non-parametric methods have no assumptions about the structure of production function and efficiency frontier is created by the observed units rather than a default situation in these methods. They are suitable for the systems that have a structure consist of a large number of inputs and outputs. Two common methods of non-parametric methods are Free Disposal Hull and Data Envelopment Analysis (DEA).

### 2.3.4 The Definition and Development of DEA

Data Envelopment Analysis (DEA) is a relatively new, linear programming based, data oriented approach which is directed to frontiers rather than central tendencies for evaluating the performance or efficiencies of a set of peer entities called Decision Making Units (DMUs) which convert multiple inputs into multiple outputs. (Cooper 2004, pp.1-3).

Basic assumption in DEA is that all firms have similar strategic goals and use the same kind of input and generate the same kind of output (Golany and Yu 1997, p. 28). DEA compares a set of homogeneous DMUs relatively and assigns an efficiency score to each DMU by finding the distance of each unit with that of its peers on the best practice (frontier). Those units that lie on the frontier are recognized as efficient, and those that do not, as inefficient. (Emrouznejad and Anouze 2009, p. 5742).

Efficiency measurement is accepted to begin in modern era with the Farrell (1957) who drew upon the work of Debreu (1951) and Koopmans (1951). Farrell (1957) aimed to define a simple measure of firm efficiency which could account for multiple inputs (Coelli 1996, p.4).

Several studies has been conducted after Farrell's study on the measurement of the efficiency and finally in 1978, during doctoral dissertation about the efficiency of a public education program of Edwardo Rhodes under the consultancy of W.W Cooper, Data Envelopment Analysis method has been developed (Cooper 2005).

The first model in DEA developed by Chames, Cooper and Rhodes and it was input-oriented and constant return to scale model (CCR model). Then, Banker, Chames and Cooper, developed the variable returns to scale model (BCC model) in 1984 (Coelli 2005).

Data Envelopment Analysis gained a big popularity in a short time and used by researchers in many studies such that Emrouznejad et al. (2008), have examined the studies regarding Data Envelopment Analysis between the years 1978 - 2006. In mentioned study is determined that there were over 4000 publications only academic journals and books considered and over 7000 publications when unpublished theses, conference presentations as well as other publications are included regarding Data Envelopment Analysis. 4000 publications were conducted by 2500 unique authors and they are over 55000 pages in total. According to Emrouznejad et al. (2008), the most popular areas in DEA studies are banking, education and health. Beside number of publications if it is wondered the methodological developments in DEA see Cook, W.D, and Seiford, L.M, 2009.

### 2.3.5 Stages in DEA Implementation

There are four stages in a Data Envelopment Analysis implementation generally (Ramanathan 2003, p. 172-177):

a) Determination of DMUs to be analyzed,
b) Determination of appropriate inputs and outputs for the model,
c) Determination of right DEA model for the problem,
d) Evaluation of results and post-DEA analysis.

#### 2.3.5.1 Determination of DMUs

There are two critical criteria to take in consideration when selecting and determining the Decision Making Units (DMUs): Homogeneity and number of DMUs (Ramanathan, 2003 p. 173).

The DMUs which perform the same tasks with similar objectives, work in the same market conditions, except for differences in density and size of the units have similar inputs and outputs may be considered as a homogeneous (Baysal and Toklu 2001).

There are two generally accepted rules in literature to determine the sufficient number of DMUs:

(a) The number of DMUs should be at least more than twice of the sum of the number of inputs and outputs (Dyson et al. 2001),
(b) The number of DMUs should be at least the maximum of either the product of the numbers of inputs and outputs or three times of the sum of the number of inputs and outputs (Cooper et al. 2001).

#### 2.3.5.2 Determination of inputs and outputs

In the literature there is not a standard approach how to determine inputs and outputs. Usually considering the number of DMUs in terms of homogeneity inputs and outputs are determined as a result of subjective assessments for the specific problem.

As required by DEA method inputs and outputs must have positive value. Inputs and outputs can be in different measurement units. In addition, it is a preferred situation that the number of input variables greater than the number of output variables (Tankersley, 1996). In principle to have more accurate efficiency values, to have smaller values for inputs and greater values for outputs is a preferred situation (Cooper et al. 2000).

#### 2.3.5.3 Determination of the model and solving the model

DEA models can basically be categorized as input oriented or output oriented and variable returns to scale or constant returns to scale.

Essentially, the orientation can be selected according to which quantities (inputs or outputs) can be most controlled. Furthermore, in many instances, the choice of orientation has only a limited effect on the efficiency scores obtained (Coelli 2005, p. 180).

The selection either constant returns to scale or variable returns to scale models is determined to consider the effect of the scale on the performance of DMUs and generally depends on the specific application (Ramanathan 2003, p. 175).

In order to solve DEA models, linear programming package programs such as LINDO, GAMS can be used also special software for DEA such as DEA Solver, EMS, DEA Frontier, DEA Excel Solver, Pioneer, DEAP can be used. If preferred DEA models can be solved by using Microsoft Excel Solver Add-in.

#### 2.3.5.4 Evaluation of results

The findings that can be obtained after implementation of DEA can be summarized as follows (Ulucan 2002):

- Efficient Decision Making Units,
- Decision Making Units that are not efficient,
- Amount of excess resources used by inefficient DMUs,
- The level of outputs that should be produced by inefficient DMUs with existing input level,
- Reference sets of inefficient DMUs which consist of efficient DMUs.

To confirm the robustness of the results after application DEA to make a sensitivity analysis can be useful. In this sense, it may need to examine carefully a DMU that has a small number of DMUs which take it as a reference. In addition, if there is data for more than one period change in efficiency can be analyzed by Malmquist Index (Ramanathan 2003, pp. 176-177).

### 2.3.6 Strengths of Data Envelopment Analysis

The strengths of DEA can be listed as follows (Kecek 2010, p. 80; Lorcu 2008, pp. 157-159):

- DEA does not need to have specific functional forms of relations between inputs and outputs,
- In DEA applications a large number of inputs and outputs can be considered at the same time,
- Inputs and outputs can be expressed in different units, thus there is no need to do conversions,
- The weights of inputs and outputs are determined by the model,
- DEA directed to frontiers rather than central tendencies.

### 2.3.7 Weaknesses of Data Envelopment Analysis

The weaknesses of DEA can be listed as follows (Özcan 2007, p. 30; Kecek 2010, p. 81):

- In case, an important input or output is left out of research the results may be misleading and biased,
- Compared with the number of inputs and outputs if the number of DMUs is not sufficient the number of effective units would be much more than the real situation,
- DEA provides a static analysis not dynamic,
- DEA is very sensitive to frontiers and measurement errors,
- DEA measures the relative efficiency and does not give information about the absolute efficiency,
- DEA results may not be suitable for statistical hypothesis testing.

### 2.3.8 Basic DEA Models

In accordance with developer's initials of surnames, constant returns to scale models are named as CCR models; variable returns to scale models are named BCC models. In the following pages, according to the distinction of being input or output-oriented, CCR and BCC models will be described mathematically.

#### 2.3.8.1 Input oriented CCR model

Decision Making Unit (DMU) to refer to any entity that is to be evaluated in terms of its abilities to convert inputs into outputs. In DEA model there are n DMUs to be evaluated that implies that model is solved n times. Each DMU consumes varying amounts of m inputs to produce s different outputs as such $DMU_j$ consumes $x_{ij}$ amount of input i and produces $y_{rj}$ amount of output r (Cooper 2004, p.8).

As $u_r$ is the weight of output r and $v_i$ is the weight of input i, the ratio form of CCR is as follows:

$$\max h_o(u,v) = \frac{\sum_{r=1}^{s} u_r y_{ro}}{\sum_{i=1}^{m} v_i x_{io}} \qquad \textbf{(2.1)}$$

Subject to,

$$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=i}^{m} v_i x_{ij}} \leq 1 \qquad j=1,2,3,\ldots\ldots,n$$

$$u_r, v_i \geq \varepsilon > 0; \qquad r=1,2,\ldots s;\ i=1,2,\ldots m$$

Here, ε is a number smaller than any real positive number. It is included in the constraints to ensure weights to be greater than zero. In addition, it is included in dual problems which will be discussed in the next page, to prevent slack variables affect the objective function.

Due to the above solution can generate an infinite number of solutions, using Chames and Cooper (1962)'s transformation the ratio form is transformed to linear programming form equivalent to the ratio form. However, in this form (u, v) becomes (μ, v).
Linear programming form of CCR is as follows:

$$\max z = \sum_{r=1}^{s} \mu_r y_{ro} \qquad \textbf{(2.2)}$$

Subject to,

$$\sum_{r=1}^{s} \mu_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \leq 0$$

$$\sum_{i=1}^{m} v_i x_{io} = 1$$

$$\mu_r, v_i \geq \varepsilon > 0$$

Because of solution of linear programming form is time consuming and the difficulty in determining reference set and the redundant inputs and outputs by taking dual of the model a new model is created, this model is called the envelopment model. Dual model is as follows:

$$\min \theta - \varepsilon\left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+\right) \qquad \textbf{(2.3)}$$

Subject to,

$$\sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- = \theta x_{io}$$

$$\sum_{j=1}^{n} y_{rj}\lambda_j - s_r^+ = y_{ro}$$

$$\lambda_j, s_i^-, s_r^+ \geq 0 \quad ; j=1,2,3,....,n \; ; \; r=1,2,...s \; ; \; i=1,2,...m$$

In dual formulation;

$\theta$ : is shrinkage coefficient, which determines how much a DMU's inputs can be reduced radially,

$\lambda_j$ : is the weight of reference,

$s_i^-$: is the slack variable for input i of a DMU,

$s_r^+$ : is the slack variable for output r of a DMU.

In fact, the dual form is a result of unification of two linear programming equations [(4) and (5)] that need to be solved separately and successively. They are as follows:

$$\theta^* = min\theta \qquad \textbf{(2.4)}$$

$$\sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- \leq \theta x_{io}$$

$$\sum_{j=1}^{n} y_{rj}\lambda_j - s_r^+ \geq y_{ro}$$

$$\lambda_j \geq 0 \quad ; j=1,2,3,....,n\ ;\ r=1,2,...s\ ;\ i=1,2,...m$$

$$\max\left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+\right) \qquad \textbf{(2.5)}$$

$$\sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- = \theta x_{io}$$

$$\sum_{j=1}^{n} y_{rj}\lambda_j - s_r^+ = y_{ro}$$

$$\lambda_j, s_i^-, s_r^+ \geq 0 \quad ; j=1,2,3,....,n\ ;\ r=1,2,...s\ ;\ i=1,2,...m$$

An inefficient $DMU_o$ ($\theta < 1$) can be efficient by reducing each input as $(1-\theta)x_{io} + s_i^-$ or by increasing each output as $s_r^+$ .

For all types of DEA models, in order to obtain 100percent efficiency, following two conditions must be satisfied at the same time;

(i) $\theta^*$=1

(ii) All slacks are zero ($s^{-^*} = s^{+^*} = 0$)

### 2.3.8.2 Output oriented CCR model

While input oriented CCR model is maximizing output to input ratio, output oriented CCR model aims to minimize input to output ratio.

The ratio form of output oriented CCR model is as follows:

$$\min \sum_{i=1}^{m} v_i x_{io} \,/\, \sum_{r=1}^{s} u_r y_{ro} \qquad \textbf{(2.6)}$$

Subject to,

$$\frac{\sum_{i=i}^{m} v_i x_{ij}}{\sum_{r=1}^{s} u_r y_{rj}} \geq 1 \qquad j=1,2,3,\ldots,n$$

$$u_r, v_i \geq \varepsilon > 0; \qquad r=1,2,\ldots s;\ i=1,2,\ldots m$$

The linear programming formulation of the ratio form is as follows:

$$\min q = \sum_{i=1}^{m} v_i x_{io} \qquad \textbf{(2.7)}$$

subject to,

$$\sum_{i=1}^{m} v_i x_{ij} - \sum_{r=1}^{s} \mu_r y_{rj} \geq 0$$

$$\sum_{r=1}^{s} \mu_r y_{ro} = 1$$

$$\mu_r, v_i \geq \varepsilon > 0 \quad j=1,2,3,\ldots,n\ ;\ \ r=1,2,\ldots s\ \ ;\ i=1,2,\ldots m$$

Finally dual form of output oriented CCR model is as follows:

$$\max \phi + \varepsilon\left( \sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+ \right) \qquad \textbf{(2.8)}$$

Subject to,

$$\sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- = x_{io}$$

$$\sum_{j=1}^{n} y_{rj}\lambda_j - s_r^+ = \phi y_{ro}$$

$\lambda_j, s_i^-, s_r^+ \geq 0$ ; *j=1,2,3,....,n ; r=1,2,...s ; i=1,2,...m*

An inefficient $DMU_o$ can be efficient by increasing each output as $(\emptyset - 1)y_{ro} + s_r^+$ or by reducing each input as $s_i^-$

### 2.3.8.3 Input oriented BCC model

The differences between CCR and BCC models are the convexity constraint $\sum_{j=1}^{n} \lambda_j = 1$ and variable $\mu_o$ in BCC model (Yun 2004).

The linear programming form of input oriented BCC is as follows (Banker et al. 2004):

$$\text{maxz} = \sum_{r=1}^{s} \mu_r y_{ro} - \mu_o \qquad \textbf{(2.9)}$$

Subject to,

$$\sum_{r=1}^{s} \mu_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} - \mu_o \leq 0$$

$$\sum_{i=1}^{m} v_i x_{io} = 1$$

$\mu_r, v_i \geq \varepsilon > 0$ ; *j=1,2,3,....,n ; r=1,2,...s ; i=1,2,...m;* $\mu_o = urs$

The dual form of input oriented BCC model is as follows:

$$\min\ \theta - \varepsilon\left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+\right) \qquad \textbf{(2.10)}$$

Subject to,

$$\sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- = \theta x_{io}$$

$$\sum_{j=1}^{n} y_{rj}\lambda_j - s_r^+ = y_{ro}$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j, s_i^-, s_r^+ \geq 0 \quad ; \; j=1,2,3,....,n \; ; \; r=1,2,...s \; ; \; i=1,2,...m$$

An inefficient $DMU_o$ $(\theta < 1)$ can be efficient by reducing each input as $(1-\theta)x_{io} + s_i^-$ or by increasing each output as $s_r^+$.

#### 2.3.8.4 Output oriented BCC model

The linear programming form of input oriented BCC model is as follows:

$$\text{minq} = \sum_{i=1}^{m} v_i x_{io} - v_o \qquad \textbf{(2.11)}$$

Subject to,

$$\sum_{i=1}^{m} v_i x_{ij} - \sum_{r=1}^{s} \mu_r y_{rj} - v_o \geq 0$$

$$\sum_{r=1}^{s} \mu_r y_{ro} = 1$$

$$\mu_r, v_i \geq \varepsilon > 0 \; ; j=1,2,3,....,n \; ; \; r=1,2,...s \; ; \; i=1,2,...m$$

The dual form of input oriented BCC model is as follows:

$$\max \phi + \varepsilon\left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+\right) \qquad \textbf{(2.12)}$$

Subject to,

$$\sum_{j=1}^{n} x_{ij}\lambda_j + s_i = x_{io}$$

$$\sum_{j=1}^{n} y_{rj}\lambda_j - s_r^+ = \phi y_{ro}$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$\lambda_j, s_i^-, s_r^+ \geq 0$ ; *j=1,2,3,....,n ; r=1,2,...s ; i=1,2,...m*

An inefficient $DMU_o$ ($\emptyset < 1$) can be efficient by increasing each output as $(\emptyset\text{-}1)y_{ro} + s_r^+$ or by reducing each input as $s_i^-$ .

### 2.3.9 Malmquist Total Factor Productivity Index

Malmquist Total Factor Productivity Index is product of efficiency change by technical change. It measures total factor productivity change over time using distance functions. As Mohammadi and Ranaei (2011) stated, Malmquist Total Factor Productivity Index do not require behavioral assumptions such as cost minimization, profit maximization or price information which makes it useful compared to other indexes.

In fact original Malmquist index has been formulated by Caves et al. (1982). Fare et al. made some modifications on the formulation of Caves et al. (1982). They called Caves et al. (1982) as CCD.

Following Fare et al. (1994) derivation of index will be given below.

$x^t \in R_+^N$ and $y^t \in R_+^M$ are, respectively, the input vectors and output vectors. The production technology $S^t$ models the transformation of inputs, $x^t \in R_+^N$, into outputs, $y^t \in R_+^M$.

Here,

$$S^t = \{(x^t, y^t) \mid x^t \text{ can produce } y^t\} \quad \textbf{(2.13)}$$

Fare, Grosskopf, Norris & Zhang (1994) followed Shephard (1970) to define the output distance function at *t* as:

$$D_0^t(x^t, y^t) = \inf\{\theta : (x^t, y^t / \theta) \in S^t\} = (\sup\{\theta : (x^t, \theta y^t) \in S^t\}) \quad \textbf{(2.14)}$$

Note that, $D_0^t(x^t, y^t) \leq 1$ if and only if $(x^t, y^t) \in S^t$, and $D_0^t(x^t, y^t) = 1$ if and only if $(x^t, y^t)$ is on the boundary of the technology.

To define the Malmquist index, Fare et al. (1994) defined distance functions with respect to two different time periods:

$$D_0^t(x^{t+1}, y^{t+1}) = \inf\{\theta : (x^{t+1}, y^{t+1} / \theta) \in S^t\} \quad \textbf{(2.15)}$$

and

$$D_0^{t+1}(x^t, y^t) = \inf\{\theta : x^t, y^t / \theta) \in S^{t+1}\} \quad \textbf{(2.16)}$$

The distance function in (2.15) measures the maximal proportional change in output required to make $(x^{t+1}, y^{t+1})$ feasible in relation to technology at time *t*. Similarly, the distance function in (2.16) measures the maximal proportional change in output required to make $(x^t, y^t)$ feasible in relation to technology at time *t + 1*.

Caves et al. (1982) – CCD define the Malmquist productivity index as

$$M_{CCD}^t = \frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)} \quad \textbf{(2.17)}$$

and

$$M_{CCD}^{t+1} = \frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^{t+1}, y^{t+1})} \frac{D_o^t(x^t, y^t)}{D_o^{t+1}(x^t, y^t)} \quad \textbf{(2.18)}$$

In (2.17) reference technology is taken as t, in (2.18) it is t+1. Fare et al. (1994) specify the output-based Malmquist productivity change index as the geometric mean of (2.17) an (2.18) so Malmquist TFP productivity index can then be expressed as:

$$M_o(x^{t+1},y^{t+1},x^t,y^t) = \left[ \frac{D_o^{t+1}(x^{t+1},y^{t+1})}{D_o^t(x^t,y^t)} \; \frac{D_o^t(x^{t+1},y^{t+1})}{D_o^{t+1}(x^{t+1},y^{t+1})} \frac{D_o^t(x^t,y^t)}{D_o^{t+1}(x^t,y^t)} \right]^{\frac{1}{2}} \quad \textbf{(2.19)}$$

The term outside the brackets shows the change in technical efficiency while the geometric mean of the two ratios inside the brackets measures the shift in technology between the two periods *t* and *t + 1;* this could be called technological progress. Thus;

$$\text{Efficiency change} = \frac{D_o^{t+1}(x^{t+1},y^{t+1})}{D_o^t(x^t,y^t)} \quad \frac{D_o^{t+1}(x^{t+1},y^{t+1})}{D_o^t(x^t,y^t)} \quad \textbf{(2.20)}$$

$$\text{Technical change} = \frac{D_o^t(x^{t+1},y^{t+1})}{D_o^{t+1}(x^{t+1},y^{t+1})} \frac{D_o^t(x^t,y^t)}{D_o^{t+1}(x^t,y^t)}^{\frac{1}{2}} \quad \textbf{(2.21)}$$

In each of the formulas above, a value greater than one indicates an improvement and a value smaller than one presents deteriorations in performance over time.

### 2.3.10 Fuzzy Data Envelopment Analysis

In this subsection first general information about Fuzzy Data Envelopment Analysis approaches will be given then one of these approaches, which is used in this study, Wang, Greatbanks and Yang (2005) LP formulation and efficiency ranking methodology will be explained.

#### 2.3.10.1 Fuzzy DEA Approaches

Kao and Liu (2011) states that although in the real world, some observations are difficult to measure precisely, observations are missing and need to be estimated or the data need to be predicted, classical DEA approach is sensitive to data variations. In these situations crisp values are assumed to represent imprecise data and the notion of fuzziness is used.

There are plenty of models which attempts to use fuzzy notion in Data Envelopment Analysis. They are called as Fuzzy Data Envelopment Analysis (FDEA) Models.

The leading study incorporating fuzziness into the classical DEA models is Sengupta (1992). Sengupta (1992) defines tolerance levels on both the objective function and constraint violations (Hatami-Marbini et al., 2011).

In their article "*A taxonomy and review of the fuzzy data envelopment analysis literature: Two decades in the making*" Hatami-Marbini et al. (2011) classifies FDEA models as five categories.

a) The tolerance approach: In this approach the main idea is to incorporate uncertainty into the DEA models by defining tolerance levels on constraint violations. It is introduced by Sengupta (1992).

b) The α-level based approach: The a-level approach is one of the most used approaches fuzzy DEA model. This approach tries to find the lower and upper bounds of the α-level of the membership functions of the efficiency scores. It is introduced by Girod (1996).

c) The fuzzy ranking approach: This approach tries to find the fuzzy efficiency scores of the DMUs using fuzzy linear programs which require ranking fuzzy sets. It is introduced by Guo and Tanaka (2001).

d) The possibility approach: In this approach fuzzy variable is associated with a possibility distribution in the same manner that a random variable is associated with a probability distribution. Guo et al. (2000) was the first who introduced this approach.

e) Other developments in fuzzy DEA: In this category there are models that do not fall into the first four categories.

Hatami-Marbini et al. (2011) present a table (see Table 2.1) about the related studies in each approach mentiod above.

In their literature survey Hatami-Marbini et al. (2011) also presents a figure of number of related studies using Fuzzy DEA. From Figure 2.1 it can be seen that number of studies related FDEA increasing by the time.

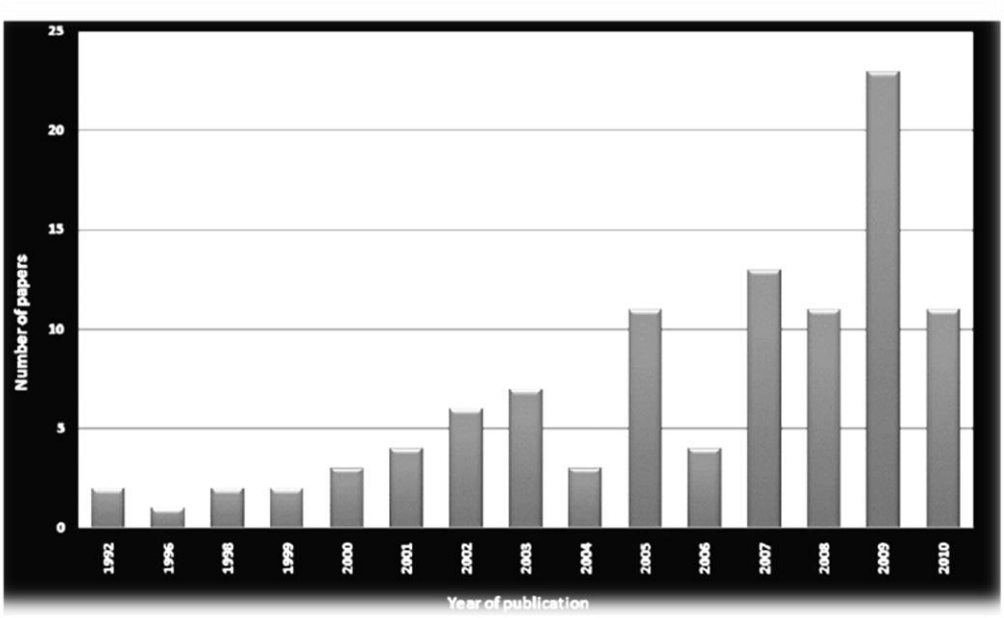


**Figure 2.1: Fuzzy DEA studies between 1992-2010**
**Source: Hatami-Marbini et al., 2011**

**Table 2.1: Classification FDEA approaches and related studies**

| The tolerance approach | Sengupta (1992a) | Sengupta (1992b) |
|---|---|---|
| The a-level based approach | Azadeh and Alem (2010) | Chiang and Che (2010) |
| | Zerafat Angiz et al. (2010a) | Hatami-Marbini et al. (2010a) |
| | Hatami-Marbini et al. (in pressd) | Hatami-Marbini and Saati (2009) |
| | Saati and Memariani (2009) | Tlig and Rebai (2009) |
| | Noura and Saljooghi (2009) | Jahanshahloo et al. (2009a) |
| | Wang et al. (2009b) | Hosseinzadeh Lotfi et al. (2009a) |
| | Liu and Chuang (2009) | Li and Yang (2008) |
| | Karsak (2008) | Azadeh et al. (2008) |
| | Ghapanchi et al. (2008) | Liu (2008) |
| | Hosseinzadeh Lotfi et al. (2007c) | Saneifard et al. (2007) |
| | Allahviranloo et al. (2007) | Azadeh et al. (2007) |
| | Kuo and Wang (2007) | Kao and Liu (2007) |
| | Liu et al. (2007) | Jahanshahloo et al. (2007b) |
| | Zhang et al. (2005) | Saati and Memariani (2005) |
| | Wu et al. (2005) | Hsu (2005) |
| | Kao and Liu (2005) | Triantis (2003) |
| | Kao and Liu (2003) | Saati et al. (2002) |
| | Entani et al. (2002) | Guh (2001) |
| | Chen (2001) | Kao (2001) |
| | Kao and Liu (2000b) | Kao and Liu (2000a) |
| | Girod and Triantis (1999) | Meada et al. (1998) |
| The fuzzy ranking approach | Triantis and Girod (1998) | Girod (1996) |
| | Hatami-Marbini et al. (2010b) | Hatami-Marbini et al. (in pressc) |
| | Hatami-Marbini et al. (in presse) | Hatami-Marbini et al. (2009) |
| | Jahanshahloo et al. (2009b) | Soleimani-damaneh (2009) |
| | Hosseinzadeh Lotfi et al. (2009b) | Bagherzadeh valami (2009) |
| | Guo (2009) | Hosseinzadeh Lotfi et al. (2009c) |
| | Juan (2009) | Sanei et al. (2009) |
| | Zhou et al. (2008) | Guo and Tanaka (2008) |
| | Noora and Karami (2008) | Soleimani-Damaneh (2008) |
| | Jahanshahloo et al. (2008) | Hosseinzadeh Lotfi and Mansouri (2008) |
| | Hosseinzadeh Lotfi et al. (2007b) | Jahanshahloo et al. (2007a) |
| | Pal et al. (2007) | Hosseinzadeh Lotfi et al. (2007a) |
| | Soleimani-damaneh et al. (2006) | Saati and Memariani (2006) |
| | Lee et al. (2005) | Molavi et al. (2005) |
| | Jahanshahloo et al. (2004a) | Dia (2004) |
| | Lee (2004) | Leon et al. (2003) |
| | Lertworasirikul (2002) | Guo and Tanaka (2001) |
| The possibility approach | Wen et al. (2010) | Khodabakhshi et al. (2010) |
| | Wen and Li (2009) | Jiang and Yang (2007) |
| | Wu et al. (2006) | Garcia et al. (2005) |
| | Ramezanzadeh et al. (2005) | Lertworasirikul et al. (2003a) |
| | Lertworasirikul et al. (2003b) | Lertworasirikul et al. (2003c) |
| | Lertworasirikul et al. (2002a) | Lertworasirikul et al. (2002b) |
| | Lertworasirikul (2002) | Guo et al. (2000) |
| Other developments in fuzzy DEA | Zerafat Angiz et al. (2010b) | Qin and Liu (2010) |
| | Wang et al. (2009a) | Luban (2009) |
| | Qin et al. (2009) | Qin and Liu (2009) |
| | Uemura (2006) | Wang et al. (2005) |
| | Hougaard (2005) | Sheth and Triantis (2003) |
| | Hougaard (1999) | |

**Source: Hatami-Marbini et al. (2011)**

### 2.3.10.2 Wang, Greatbanks and Yang (2005) Approach

In the application chapter of this study, Wang, Greatbanks and Yang (2005) approach will be used as fuzzy data envelopment model and ranking methodology. Wang, Greatbanks and Yang (2005)'s interval DEA, called fuzzy DEA in this study, approach will be explained below in detail by summarizing important parts of Wang, Greatbanks and Yang (2005).

In order to measure the upper and lower bounds of the efficiency of $DMU_0$, Wang, Greatbanks and Yang (2005) construct the following pair of fractional programming models for $DMU_0$ for lower and upper bound efficiency respectively:

Fractional Model for Lower Bound Efficiency:

$$\text{Maximize } \theta_{j0}^{L} = \frac{\sum_{r=1}^{s} u_r y_{rj0}^{L}}{\sum_{i=1}^{m} v_i x_{ij0}^{L}} \qquad \textbf{(2.22)}$$

Subject to

$$\theta_j^U = \frac{\sum_{r=1}^{s} u_r y_{rj}^{U}}{\sum_{i=1}^{m} v_i x_{ij}^{L}} \leq 1, \quad j=1,2,\ldots,n,$$

$$u_r,\ v_i \geq \varepsilon \quad \forall r, i.$$

Fractional Model for Upper Bound Efficiency:

$$\text{Maximize } \theta_{j0}^{U} = \frac{\sum_{r=1}^{s} u_r y_{rj0}^{U}}{\sum_{i=1}^{m} v_i x_{ij0}^{L}} \qquad \textbf{(2.23)}$$

Subject to

$$\theta_j^U = \frac{\sum_{r=1}^{s} u_r y_{rj}^{U}}{\sum_{i=1}^{m} v_i x_{ij}^{L}} \leq 1, \quad j = 1,2,\ldots,n,$$

$$u_r, v_i \geq \varepsilon \quad \forall r, i.$$

Applying Charnes–Cooper transformation to the above pair of fractional programming models they can be simplified as the following equivalent LP models:
LP Model for Lower Bound Efficiency:

$$\text{Maximize } \theta_{j0}^{L} = \sum_{r=1}^{s} u_r \, y_{rj0}^{L} \qquad \textbf{(2.24)}$$

Subject to

$$\sum_{i=1}^{m} v_i x_{ij0}^{U} = 1,$$

$$\sum_{r=1}^{s} u_r y_{rj}^{U} - \sum_{i=1}^{m} v_i x_{ij}^{L} \leq 0, \quad j = 1,2,..,n$$

$$u_r, v_i \geq \varepsilon \quad \forall r, i.$$

LP Model for Upper Bound Efficiency:

$$\text{Maximize } \theta_{j0}^{L} = \sum_{r=1}^{s} u_r \, y_{rj0}^{U} \qquad \textbf{(2.25)}$$

Subject to

$$\sum_{i=1}^{m} v_i x_{ij0}^{L} = 1,$$

$$\sum_{r=1}^{s} u_r y_{rj}^{U} - \sum_{i=1}^{m} v_i x_{ij}^{L} \leq 0, \quad j = 1,2,..,n$$

$$u_r, v_i \geq \varepsilon \quad \forall r, i.$$

In the models (2.24, 2.25) above $\theta_{j0}^{U}$ has the meaning that for the best possible relative efficiency achieved by $DMU_0$ when all the DMUs are in the state of best production activity, while $\theta_{j0}^{L}$ has the meaning that for the lower bound of the best possible relative efficiency of $DMU_0$. Thus they form a possible best relative efficiency interval [ $\theta_{j0}^{L}$, $\theta_{j0}^{U}$].

In their study authors explain why two different data are used for $DMU_0$ in the same model by the following arguments (Wang et al. 2005), p.354):

(1) $\theta_{j0}^{L}$ in (2.22) is measured not only relative to the other $(n-1)$ DMUs, but also relative to the best production activity of $DMU_0$ itself.

(2) Let $DMU_0^{'}$ be a virtual DMU that consumes the upper bound inputs of $DMU_0$ and produces only the lower bound outputs of $DMU_0$. Since $DMU_0^{'}$ represents the worst production activity of $DMU_0$, the best relative efficiency of $DMU_0^{'}$ can therefore be used to characterize the lower bound efficiency of $DMU_0$. Accordingly, model (2.22) can be considered as conventional DEA model evaluating $DMU_0^{'}$ using $(n+1)$ DMUs,

where $DMU_i$ ($i = 1, \ldots, n$) consumes the least inputs to produce the most outputs, which leads to the efficiency of $DMU_0^{'}$ to be less than one automatically. It is no wonder that $DMU_0$ can be the reference DMU of $DMU_0^{'}$.

(3) Production frontier is determined by the best production activities of the *n* DMUs regardless of their worst production activities. If the best production activity of $DMU_0$ were removed from the model, the production frontier would be changed and would be different from DMU to DMU, which would result in the efficiencies obtained incomparable.

### 2.3.10.3 Ranking Interval Efficiencies: The Minimax Regret Approach

Since the final efficiency score for each DMU is characterized by an interval, a ranking approach is thus needed for comparing and ranking the efficiencies of DMUs. Wang, Greatbanks and Yang (2005) introduce a simple and practical approach for this aim. They called this approach as the minimax regret approach (MRA). MRA is explained in Wang, Greatbanks and Yang (2005, pp. 362-363) as follows.

Let $A_i = [a_i^L, a_i^U] = m(A_i)$, $w(A_i)$ for (i = 1,2,…,n) be the efficiency intervals of n DMUs, where $m(A_i) = \frac{1}{2}(a_i^R + a_i^L)$ and $w(A_i) = \frac{1}{2}(a_i^R - a_i^L)$ are their midpoints and widths respectively. Suppose $A_i = [a_i^L, a_i^U]$ is chosen as the best efficiency interval.

Let $b = max_{j \neq i}\{a_j^U\}$. The maximum loss of efficiency or regret is given by

$$max\ (r_i) = b - a_i^L = max_{j \neq i}\{a_j^U\} - a_i^L. \qquad \textbf{(2.26)}$$

If $r_i = 0$ there will be no loss of efficiency and no regret. Combining the above two situations, we have

$$max(r_i) = max\,[max_{j \neq i}\{a_j^U\} - a_i^L, 0]\,. \qquad \textbf{(2.27)}$$

Thus, the minimax regret criterion will choose the efficiency interval satisfying the following condition as the best efficiency interval:

$$min_i\{max(r_i)\} = min_i(\ max\ [max_{j\neq i}\ \{a_j^U\} -\ a_i^L\ , 0]\ ) \qquad \textbf{(2.28)}$$

Wang, Greatbanks and Yang (2005) define the maximum loss of efficiency (also called maximum regret) of each efficiency interval $A_i$ as:

$$R(A_i) = max\ [max_{j\neq i}\ \{a_j^U\} -\ a_i^L\ , 0]$$
$$= max\big[\ max_{j\neq i}\ \{m(A_j) +\ w(A_j)\} -\ \big(m(A_i) -\ w(A_i)\big), 0\big].$$

In that situation the efficiency interval with the smallest maximum loss of efficiency will be the most desirable efficiency interval. In order to be able to generate a ranking for a set of efficiency intervals using the maximum losses of efficiency, the following eliminating steps are applied:

*Step* 1: Calculate the maximum loss of efficiency of each efficiency interval and choose a most desirable efficiency interval that has the smallest maximum loss of efficiency. Suppose $A_{i_1}$ is selected, where $1 \leq i_1 \leq n$.

*Step* 2: Eliminate $A_{i_1}$ from the consideration, recalculate the maximum loss of efficiency of every efficiency interval and determine a most desirable efficiency interval from the remaining *(n*−1*)* efficiency intervals. Suppose $A_{i_2}$ is chosen, where $1 \leq i_1 \leq n$ but $i_2 \neq i_1$.

*Step* 3: Eliminate $A_{i_2}$ from the further consideration, recalculate the maximum loss of efficiency of each efficiency interval and determine a most desirable efficiency interval $A_{i_3}$ from the remaining (n−2) efficiency intervals.

*Step* 4: Repeat the above eliminating process until only one efficiency interval $A_{i_n}$ is left. The final ranking is $A_{i_1} \succ A_{i_2} \succ \cdots \succ A_{i_n}$ , where the symbol '$\succ$' means 'is superior to'.

For properties of MRA in detail see Wang, Greatbanks and Yang (2005, p.363).

# 3. APPLICATION AND RESULTS

## 3.1 THE AIM AND THE METHODOLOGY

Due to the positive contribution of the stock markets to the economic growth which is explained detailed in Chapter 2 of this study, almost every country tries develop their stock markets. In the application part of the study it is aimed to give some insights to decision makers about how their stock markets use the potential of their country, how is their stock market efficiency compared to other countries, which countries they can take as reference, what their targets should be in order to be efficient.

In this study, the data which belong to 45 countries are used. 25 of them are developed countries and 20 of them are developing countries according to the World Bank classification in 2009. The 45 countries represent 90percent of whole world in terms of market capitalization value and 95 percent of the whole world in terms of trading volume.

The three-year data for 2007, 2008 and 2009 were used in this study. The data for 2010 could not use because they were not available while this study was preparing.

Classical Data Envelopment Analysis and Fuzzy Data Envelopment Analysis are used as a methodology of analyzing the stock market efficiencies of the selected countries.

There are four stages in the implementation of the Data Envelopment Analysis:

a) Determination of the Decision Making Units (DMUs) to be analyzed,
b) Determination of the appropriate inputs and outputs,
c) Determination of the DEA model to be used,
d) Evaluation of results and post analysis after application of the DEA.

In the following pages of this study, the first three stages which are common to both methods (DEA and FDEA) will be explained then the fourth stage will be given with detailed analysis for two methods separately.

## 3.2 DETERMINATION OF THE DECISION MAKING UNITS

There are three important factors to be considered for determination of Decision Making Units (DMUs). (1) The homogeneity of DMUs, (2) The number of DMUs with respect to number of inputs and outputs, (3) The degree of reliability and availability of the data.

It is difficult to perfectly guarantee the homogeneity of 45 countries but assuming all countries are aware of the importance of the stock markets and their contribution to the economical growth thus have similar aims and the factors affecting the stock market development are valid in a global scale for all countries it can be stated that DMUs are homogeneous. To test the homogeneity of the countries they grouped as developed and developing and DEA model were solved separately and together. The results especially in ranking were very close so it is decided to include 45 countries in DEA model at the same time to produce more comparable results for all countries.

There are two generally accepted rules to determine the sufficient number of DMUs: (1) The number of DMUs should be at least more than twice of the sum of the number of inputs and outputs (Dyson et al., 2001), (2) The number of DMUs should be at least the maximum of either the product of the numbers of inputs and outputs or three times of the sum of the number of inputs and outputs (Cooper et al., 2001).

In the study, the number of inputs is 7 and the number of outputs is 3. All inputs and outputs will be explained in the following section. When considered that the number of DMUs is 45, it can be seen that both rules are satisfied.

The data are investigated from the reliability and availability perspective and finally 45 countries are selected for this study. The countries used as DMUs in this study are given in Table 3.1 as classified according to the development stage of the countries.

**Table 3.1: Countries included in the study**

| Developed Countries | | Developing Countries | |
|---|---|---|---|
| Australia | Korea (South) | Argentina | Mexico |
| Austria | Kuwait | Brazil | Nigeria |
| Belgium | Netherlands | Chile | Panama |
| Canada | Norway | China | Peru |
| Czech Rep. | Poland | Colombia | Philippines |
| Finland | Saudi Arabia | Egypt | Russian Federation |
| France | Singapore | India | South Africa |
| Germany | Spain | Indonesia | Thailand |
| Hungary | Sweden | Kazakhstan | Turkey |
| Ireland | Switzerland | Malaysia | Ukraine |
| Israel | United Kingdom | | |
| Italy | United States | | |
| Japan | | | |

## 3.3 DETERMINATION OF INPUTS AND OUTPUTS

### 3.3.1 Determination of Inputs

The factors that affect the stock market development which were explained in Chapter 2 can be summarized as two main categories: institutional/structural factors and macroeconomic factors. In this study, the variables which are assumed to represent these categories will be used as inputs in DEA models.

For macroeconomic factors as a representative Gross Domestic Product (GDP) and GDP per capita will be used.

In order to represent institutional/structural factors the first five pillars of Financial Development Report of World Bank will be used. Financial Development Report was first published in 2008. Each report includes evaluation about the last year before publishing. The first five pillars are namely; institutional environment, business environment, financial stability, banking financial services and non-banking financial

services. The sub pillars of these pillars are given in Table 3.2. The highest score for a pillar is 7.

**Table 3.2: The pillars and sub pillars used in Financial Development Report**

| 1st pillar: Institutional environment |
|---|
| **Financial sector liberalization** |
| Capital account liberalization |
| Commitments to WTO agreement on trade in services |
| Domestic financial sector liberalization |
| **Corporate governance** |
| Extent of incentive-based compensation |
| Efficacy of corporate boards |
| Reliance on professional management |
| Willingness to delegate |
| Strength of auditing and reporting standards |
| Ethical behavior of firms |
| Protection of minority shareholders' interests |
| **Legal and regulatory issues** |
| Burden of government regulation |
| Centralization of economic policymaking |
| Regulation of securities exchanges |
| Property rights |
| Intellectual property protection |
| Diversion of public funds |
| Public trust of politicians |
| Corruption perceptions index |
| Strength of legal rights index |
| Central bank transparency |
| **Contract enforcement** |
| Effectiveness of law-making bodies |
| Judicial independence |
| Irregular payments in judicial decisions |
| Time to enforce a contract |
| Number of procedures to enforce a contract |
| Strength of investor protection index |
| Cost of enforcing contracts |

| 2nd pillar: Business environment |
|---|
| **Human capital** |
| Quality of management schools |
| Quality of math and science education |
| Extent of staff training |
| Local availability of specialized research and training services |
| Brain drain and ease of hiring foreign labor |
| Tertiary enrollment |
| **Taxes** |
| Irregular payments in tax collection |
| Distortive effect of taxes and subsidies on competition |
| Marginal tax variation |
| Time to pay taxes |
| **Infrastructure** |
| Quality of overall infrastructure |
| Quality of telephone infrastructure |
| Internet users |
| Broadband Internet subscribers |
| Telephone lines |
| Mobile telephone subscribers |
| **Cost of doing business** |
| Cost of starting a business |
| Cost of registering property |
| Cost of closing a business |
| Time to start a business |
| Time to register property |
| Time to close a business |

| 3rd pillar: Financial stability |
|---|
| **Currency stability** |
| Change in real effective exchange rate (REER) |
| External vulnerability indicator |
| Current account balance to GDP |
| Dollarization vulnerability indicator |
| External debt to GDP (developing economies) |
| Net international investment position to GDP |
| **Banking system stability** |
| Frequency of banking crises |
| Financial strengths indicator |
| Aggregate measure of real estate bubbles |
| Financial Stress Index |
| Tier 1 capital ratio |
| Output loss during banking crises |
| **Risk of sovereign debt crisis** |
| Local currency sovereign rating |
| Foreign currency sovereign rating |
| Aggregate macroprudential indicator |
| Manageability of public debt |
| Credit default swap spreads |

| 4th pillar: Banking financial services |
|---|
| **Size index** |
| Deposit money bank assets to GDP |
| Central bank assets to GDP |
| Financial system deposits to GDP |
| M2 to GDP |
| Private credit to GDP |
| Bank deposits to GDP |
| Money market instruments to GDP |
| **Efficiency index** |
| Aggregate profitability indicator |
| Bank overhead costs |
| Public ownership of banks |
| Bank operating costs to assets |
| Non-performing bank loans to total loans |
| **Financial information disclosure** |
| Private credit bureau coverage |
| Public credit registry coverage |

| 5th pillar: Non-banking financial services |
|---|
| **IPO activity** |
| IPO market share |
| IPO proceeds amount |
| Share of world IPOs |
| **M&A activity** |
| M&A market share |
| M&A transaction value to GDP |
| Share of total number of M&A deals |
| **Insurance** |
| Life insurance density |
| Non–life insurance density |
| Real growth of direct insurance premiums |
| Life insurance coverage |
| Non–life insurance coverage |
| Relative value-added of insurance to GDP |
| **Securitization** |
| Securitization to GDP |
| Share of total number of securitization deals |

**Source: World Economic Forum Financial Development Report 2010**

### 3.3.2 Determination of Outputs

As outputs variables for DEA and FDEA models, three market-related variables are used. These variables are, market capitalization value in billion USD which is the sum of product of stock price by stock number; value traded in billion USD which the value of buying or selling through year, turnover ratio as percent, which division of the value traded to average (current year and the year before current year) market capitalization.

## 3.4 MODELS

In this study output oriented CCR and BCC models are used as classical DEA models. The score obtained from CCR score is called overall efficiency, the score obtained from BCC model is called pure technical efficiency in this study.

In order to compare and evaluate the efficiency change by the time, Malmquist Total Factor Productivity Index is used.

For Fuzzy DEA model which is using the same input and output variables as classical DEA, CCR-based Wang, Greatbanks and Yang (2005) approach is used. Lower and upper bound efficiency scores in FDEA are calculated for three $\alpha$ levels (0.25, 0.50, 0.75).

The models in classical DEA are solved by Deap Version 2.1, the FDEA model in solved by the help of Microsoft Excel 2007 Solver Add-in.

## 3.5 APPLICATION AND RESULTS OF CLASSICAL DEA

### 3.5.1 Results and Evaluation of 2007

The data used in order to solve conventional DEA for year 2007 is shown in Table 3.3. Here the first three columns include the data for output variables and the last seven columns include the data for input variables of 45 countries in alphabetical order.

For the sake of understanding the output and input variables some descriptive statistics presented in Table 3.4. Since from the literature survey it is known that the main factor that affects the other determinants of the stock market development is the stage of development of the countries, beginning with Table 3.4 most of the results is given and analyzed according to the stage of development of the countries.

As seen in Table 3.4 the average of value traded in terms of billion USD is 3,359.44 for developed countries, 581.70 for developing countries and 2,124.89 for 45 countries. The average of market capitalization in terms of billion USD is 1,852.72 for developed countries, 708.29 for developing countries and 1,349.64 for 45 countries. Similarly, the average of value turnover ratio is 136.94 for developed countries, 48.51 for developing countries and 97.64 for 45 countries.

When input variables is considered, the average values of 45 countries are 4.81 for institutional environment; 4.64 for business environment; 4.66 for financial stability; 3.91 for banking financial services; 2.80 for non-banking financial services; 1,126.54 billion USD for GDP and finally 23,955 USD for GDP per capita. There is a difference in these values depending on the stage of development as in output variables.

From Table 3.3 it can be calculated that in 2007, about 45 percent of all value traded in the world and 33 percent of world's total market capitalization value belongs to United States. The selected 15 countries that have the highest values in value traded have 94 percent share in value traded and 85 percent share in market capitalization. These 15 countries are United States, United Kingdom, China, Japan, France, Germany, Spain, Italy, Korea, Netherlands, Switzerland, Canada, Australia, India and Sweden. A graphical presentation of two important market indicators of these 15 countries is given in Figure 3.1.

## Table 3.3: Input and output values for 2007

| Country | Value Traded (Billion USD) | Market Capitalization (Billion USD) | Turnover Ratio (%) | Institutional Environment | Business Environment | Financial Stability | Banking Financial Services | Non-Banking Financial Services | GDP (Billion USD) | GDP per Capita (USD) |
|---|---|---|---|---|---|---|---|---|---|---|
| Argentina | 8.25 | 86.68 | 9.90 | 3.35 | 3.92 | 2.92 | 2.85 | 2.48 | 260.79 | 6,604 |
| Australia | 1,322.82 | 1,298.43 | 110.50 | 5.94 | 5.24 | 5.13 | 4.12 | 4.26 | 856.82 | 40,660 |
| Austria | 121.42 | 228.71 | 57.80 | 6.04 | 5.29 | 5.81 | 4.32 | 2.12 | 372.29 | 44,850 |
| Belgium | 255.69 | 386.36 | 65.30 | 5.84 | 5.00 | 5.22 | 4.37 | 2.25 | 458.62 | 43,161 |
| Brazil | 584.95 | 1,370.38 | 56.20 | 3.69 | 4.00 | 3.60 | 2.47 | 2.82 | 1,365.98 | 7,185 |
| Canada | 1,645.47 | 2,186.55 | 84.70 | 6.06 | 5.43 | 5.26 | 5.15 | 4.37 | 1,424.07 | 43,185 |
| Chile | 44.47 | 212.91 | 23.00 | 5.38 | 4.89 | 4.47 | 3.72 | 1.68 | 164.32 | 9,877 |
| China | 7,791.70 | 6,226.31 | 180.10 | 3.33 | 4.07 | 5.17 | 4.97 | 3.30 | 3,494.06 | 2,651 |
| Colombia | 10.34 | 101.96 | 13.10 | 3.80 | 3.82 | 4.27 | 3.33 | 1.89 | 207.36 | 4,675 |
| Czech Republic | 41.93 | 73.42 | 68.70 | 4.14 | 4.77 | 4.29 | 2.92 | 1.47 | 174.22 | 16,858 |
| Egypt | 53.08 | 139.29 | 45.60 | 4.07 | 3.91 | 3.41 | 3.40 | 1.75 | 130.47 | 1,630 |
| Finland | 543.34 | 369.17 | 182.00 | 6.23 | 5.76 | 5.24 | 3.08 | 2.15 | 245.95 | 46,505 |
| France | 3,418.89 | 2,771.22 | 131.50 | 5.83 | 5.20 | 5.17 | 4.55 | 5.29 | 2,594.01 | 40,644 |
| Germany | 3,363.09 | 2,105.51 | 179.70 | 6.08 | 5.41 | 5.77 | 4.85 | 4.12 | 3,329.15 | 40,468 |
| Hungary | 47.50 | 47.65 | 106.00 | 4.52 | 4.71 | 3.50 | 3.46 | 2.01 | 138.76 | 13,799 |
| India | 1,107.55 | 1,819.10 | 84.00 | 3.42 | 3.61 | 4.67 | 2.61 | 3.24 | 1,232.82 | 1,096 |
| Indonesia | 112.85 | 211.69 | 64.40 | 4.46 | 3.46 | 3.65 | 4.60 | 1.58 | 432.11 | 1,923 |
| Ireland | 136.62 | 144.03 | 88.90 | 6.01 | 5.15 | 5.45 | 4.80 | 3.15 | 259.71 | 59,608 |
| Israel | 113.46 | 236.36 | 55.40 | 5.66 | 5.00 | 4.48 | 3.85 | 2.23 | 166.99 | 23,257 |
| Italy | 2,313.48 | 1,072.69 | 220.40 | 4.66 | 4.63 | 4.82 | 4.41 | 3.35 | 2,116.20 | 35,641 |
| Japan | 6,497.19 | 4,453.47 | 141.60 | 5.88 | 5.17 | 5.71 | 4.92 | 4.50 | 4,377.94 | 34,264 |
| Kazakhstan | 8.90 | 41.38 | 20.90 | 3.14 | 3.51 | 3.58 | 3.07 | 3.56 | 104.85 | 6,772 |
| Korea | 1,974.02 | 1,123.63 | 201.60 | 5.08 | 5.42 | 4.42 | 4.81 | 3.62 | 1,049.24 | 21,653 |
| Kuwait | 120.70 | 188.05 | 76.20 | 4.06 | 4.93 | 5.44 | 3.96 | 1.07 | 114.74 | 43,087 |
| Malaysia | 150.00 | 325.66 | 53.50 | 5.14 | 4.80 | 5.18 | 5.72 | 1.93 | 186.64 | 7,028 |
| Mexico | 115.62 | 397.73 | 31.00 | 4.31 | 3.81 | 4.69 | 2.65 | 1.88 | 1,025.58 | 9,741 |
| Netherlands | 1,803.44 | 956.47 | 207.80 | 6.02 | 5.57 | 5.74 | 4.25 | 3.87 | 778.31 | 47,511 |
| Nigeria | 16.77 | 86.35 | 28.20 | 3.71 | 3.08 | 4.02 | 2.80 | 1.48 | 165.92 | 1,123 |
| Norway | 471.89 | 357.42 | 147.80 | 6.15 | 5.67 | 5.87 | 4.20 | 2.38 | 387.54 | 82,294 |
| Panama | 0.12 | 6.22 | 2.00 | 4.82 | 3.95 | 3.01 | 3.77 | 1.95 | 19.79 | 5,920 |
| Peru | 7.26 | 105.96 | 8.80 | 4.22 | 3.89 | 3.77 | 2.51 | 2.08 | 107.49 | 3,771 |
| Philippines | 29.25 | 103.22 | 34.10 | 3.60 | 3.50 | 3.32 | 2.96 | 1.78 | 144.07 | 1,624 |
| Poland | 84.57 | 207.32 | 47.50 | 3.54 | 4.56 | 4.09 | 3.21 | 1.72 | 425.32 | 11,157 |
| Russian Federation | 754.54 | 1,503.01 | 58.90 | 3.10 | 4.08 | 4.41 | 2.87 | 3.71 | 1,299.71 | 9,146 |
| Saudi Arabia | 679.84 | 515.11 | 161.50 | 4.18 | 4.54 | 5.97 | 4.07 | 1.40 | 384.08 | 15,847 |
| Singapore | 384.23 | 353.49 | 122.00 | 6.31 | 5.82 | 6.22 | 3.63 | 2.91 | 176.77 | 38,523 |
| South Africa | 425.75 | 833.55 | 55.00 | 4.58 | 4.03 | 4.72 | 4.09 | 2.42 | 286.30 | 5,933 |
| Spain | 2,962.12 | 1,800.10 | 189.70 | 5.62 | 4.80 | 5.00 | 4.84 | 3.77 | 1,440.84 | 32,105 |
| Sweden | 968.83 | 612.50 | 147.40 | 6.06 | 5.63 | 5.26 | 3.67 | 2.87 | 462.51 | 50,558 |
| Switzerland | 1,777.80 | 1,274.52 | 143.00 | 5.74 | 5.63 | 6.18 | 3.80 | 2.99 | 434.12 | 57,490 |
| Thailand | 108.21 | 196.05 | 64.20 | 4.46 | 4.24 | 4.54 | 4.45 | 1.89 | 247.11 | 3,689 |
| Turkey | 302.40 | 286.57 | 134.70 | 3.36 | 4.38 | 2.76 | 3.32 | 2.19 | 647.16 | 8,865 |
| Ukraine | 2.02 | 111.76 | 2.60 | 2.75 | 3.88 | 2.88 | 3.13 | 1.99 | 142.72 | 3,069 |
| United Kingdom | 10,324.50 | 3,858.51 | 270.10 | 6.09 | 5.34 | 4.97 | 5.51 | 6.55 | 2,799.04 | 45,901 |
| United States | 42,613.20 | 19,947.30 | 216.50 | 5.98 | 5.32 | 5.51 | 5.80 | 6.05 | 14,061.80 | 46,627 |

**Source: Worldbank World Development Indicators and WEF Financial Development Report 2008**

**Table 3.4: Some descriptive statistics of input and output values**

| | Value Traded (Billion USD) | Market Capitalization (Billion USD) | Turnover Ratio (%) | Institutional Environment | Business Environment | Financial Stability | Banking Financial Services | Non-Banking Financial Services | GDP (Billion USD) | GDP per Capita (USD) |
|---|---|---|---|---|---|---|---|---|---|---|
| Average - Developed | 3,359.44 | 1,862.72 | 136.94 | 5.51 | 5.20 | 5.22 | 4.26 | 3.22 | 1,561.16 | 39,026 |
| Average - Developing | 581.70 | 708.29 | 48.51 | 3.93 | 3.94 | 3.95 | 3.46 | 2.28 | 583.26 | 5,116 |
| Average - Total | 2,124.89 | 1,349.64 | 97.64 | 4.81 | 4.64 | 4.66 | 3.91 | 2.80 | 1,126.54 | 23,955 |
| Standard Deviation - Developed | 8,506.48 | 3,947.78 | 60.93 | 0.82 | 0.38 | 0.67 | 0.73 | 1.43 | 2,844.00 | 16,033 |
| Standard Deviation - Developing | 1,723.22 | 1,403.57 | 44.53 | 0.72 | 0.43 | 0.77 | 0.89 | 0.68 | 813.10 | 2,987 |
| Standard Deviation - Total | 6,534.52 | 3,112.58 | 69.69 | 1.10 | 0.75 | 0.95 | 0.89 | 1.24 | 2,222.34 | 20,843 |
| Minimum - Developed | 41.93 | 47.65 | 47.50 | 3.54 | 4.54 | 3.50 | 2.92 | 1.07 | 114.74 | 11,157 |
| Minimum - Developing | 0.12 | 6.22 | 2.00 | 2.75 | 3.08 | 2.76 | 2.47 | 1.48 | 19.79 | 1,096 |
| Maximum - Developed | 42,613.20 | 19,947.30 | 270.10 | 6.31 | 5.82 | 6.22 | 5.80 | 6.55 | 14,061.80 | 82,294 |
| Maximum - Developing | 7,791.70 | 6,226.31 | 180.10 | 5.38 | 4.89 | 5.18 | 5.72 | 3.71 | 3,494.06 | 9,877 |

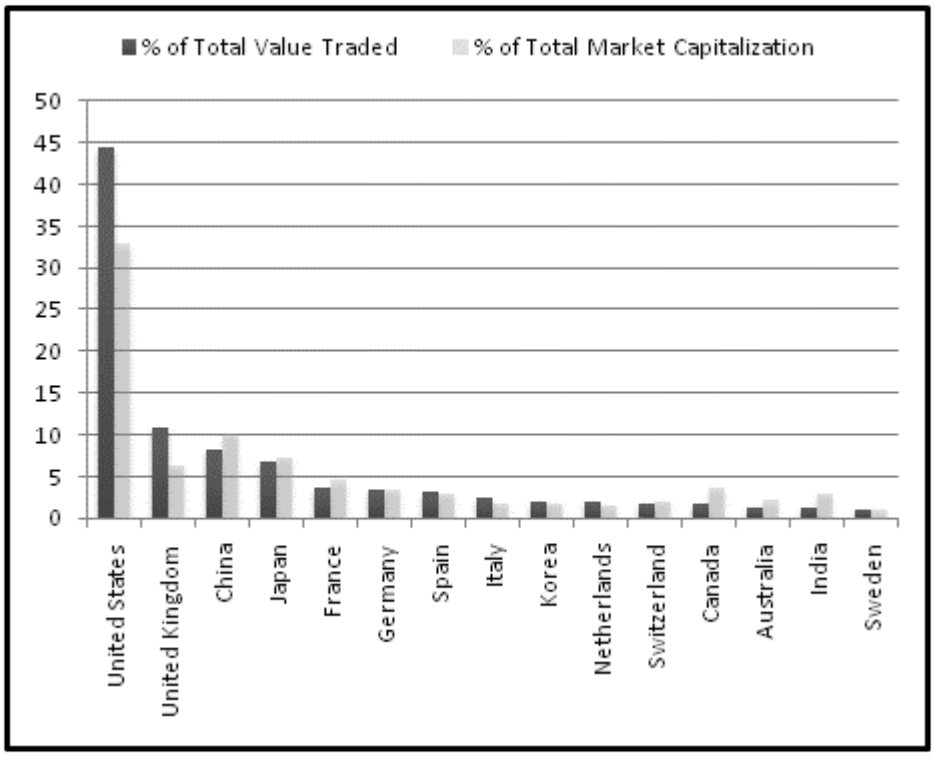


**Figure 3.1: The biggest 15 markets for 2007**

When the correlations between variables (Table 3.5) for year 2007 are inspected some implications as follows:

- Value traded and market capitalization is highly correlated whereas turnover ratio has a medium and nearly same correlation with the other two output variables.
- Value traded and market capitalization is highly correlated with GDP but not with GDP per capita.
- GDP per capita has medium or high correlation with the other input variables except GDP.
- GDP per capita is highly correlated with institutional environment, business environment and financial stability.
- Value traded and market capitalization has low correlation with institutional environment, business environment and financial stability.
- The correlation of GDP with banking and non-banking financial services is lower than the correlation with the stock market output variables.

**Table 3.5: Correlations of variables for 2007**

| | Value Traded (Billion USD) | Market Capitalization (Billion USD) | Turnover Ratio (%) | Institutional Environment | Business Environment | Financial Stability | Banking Financial Services | Non-Banking Financial Services | GDP (Billion USD) | GDP per Capita (USD) |
|---|---|---|---|---|---|---|---|---|---|---|
| Value Traded (Billion USD) | 1.00 | | | | | | | | | |
| Market Capitalization (Billion USD) | 0.98 | 1.00 | | | | | | | | |
| Turnover Ratio (%) | 0.46 | 0.46 | 1.00 | | | | | | | |
| Institutional Environment | 0.24 | 0.21 | 0.52 | 1.00 | | | | | | |
| Business Environment | 0.22 | 0.20 | 0.64 | 0.85 | 1.00 | | | | | |
| Financial Stability | 0.24 | 0.27 | 0.57 | 0.72 | 0.73 | 1.00 | | | | |
| Banking Financial Services | 0.48 | 0.48 | 0.58 | 0.60 | 0.52 | 0.54 | 1.00 | | | |
| Non-Banking Financial Services | 0.60 | 0.63 | 0.64 | 0.44 | 0.42 | 0.36 | 0.54 | 1.00 | | |
| GDP (Billion USD) | 0.97 | 0.98 | 0.48 | 0.23 | 0.22 | 0.27 | 0.49 | 0.66 | 1.00 | |
| GDP per Capita (USD) | 0.24 | 0.21 | 0.59 | 0.81 | 0.86 | 0.74 | 0.46 | 0.44 | 0.23 | 1.00 |

**Table 3.6: DEA efficiency scores for 2007**

| Country | Stage of Development | Overall Efficiency | Pure Technical Efficiency | Scale Efficiency | Market Capitalization (% of GDP) | Value Traded (% of GDP) | Turnover Ratio (%) |
|---|---|---|---|---|---|---|---|
| China | Developing | 1.000 | 1.000 | 1.000 | 177.61 | 222.27 | 180.10 |
| Egypt | Developing | 1.000 | 1.000 | 1.000 | 106.76 | 40.68 | 45.60 |
| Finland | Developed | 1.000 | 1.000 | 1.000 | 150.24 | 221.12 | 182.00 |
| Hungary | Developed | 1.000 | 1.000 | 1.000 | 34.34 | 34.23 | 106.00 |
| India | Developing | 1.000 | 1.000 | 1.000 | 147.56 | 89.84 | 84.00 |
| Indonesia | Developing | 1.000 | 1.000 | 1.000 | 48.98 | 26.11 | 64.40 |
| Italy | Developed | 1.000 | 1.000 | 1.000 | 50.69 | 109.32 | 220.40 |
| Korea | Developed | 1.000 | 1.000 | 1.000 | 107.09 | 188.14 | 201.60 |
| Netherlands | Developed | 1.000 | 1.000 | 1.000 | 122.89 | 231.71 | 207.80 |
| Saudi Arabia | Developed | 1.000 | 1.000 | 1.000 | 134.12 | 177.01 | 161.50 |
| Singapore | Developed | 1.000 | 1.000 | 1.000 | 199.98 | 217.36 | 122.00 |
| South Africa | Developing | 1.000 | 1.000 | 1.000 | 291.14 | 148.71 | 55.00 |
| Switzerland | Developed | 1.000 | 1.000 | 1.000 | 293.61 | 409.55 | 143.00 |
| Turkey | Developing | 1.000 | 1.000 | 1.000 | 44.28 | 46.73 | 134.70 |
| United Kingdom | Developed | 1.000 | 1.000 | 1.000 | 137.85 | 368.86 | 270.10 |
| United States | Developed | 1.000 | 1.000 | 1.000 | 142.37 | 304.15 | 216.50 |
| Kuwait | Developed | 0.961 | 1.000 | 0.961 | 163.89 | 105.20 | 76.20 |
| Spain | Developed | 0.931 | 0.954 | 0.975 | 124.93 | 205.58 | 189.70 |
| Thailand | Developing | 0.924 | 0.943 | 0.980 | 79.34 | 43.79 | 64.20 |
| Malaysia | Developing | 0.836 | 0.900 | 0.929 | 175.11 | 80.65 | 53.50 |
| Sweden | Developed | 0.812 | 0.816 | 0.996 | 132.43 | 209.47 | 147.40 |
| Nigeria | Developing | 0.806 | 1.000 | 0.806 | 52.04 | 10.11 | 28.20 |
| Philippines | Developing | 0.794 | 1.000 | 0.794 | 71.66 | 20.31 | 34.10 |
| Norway | Developed | 0.778 | 0.794 | 0.980 | 92.23 | 121.77 | 147.80 |
| Canada | Developed | 0.775 | 0.782 | 0.991 | 153.54 | 115.55 | 84.70 |
| Germany | Developed | 0.755 | 0.782 | 0.965 | 63.35 | 101.19 | 179.70 |
| Australia | Developed | 0.752 | 0.774 | 0.972 | 151.54 | 154.39 | 110.50 |
| Japan | Developed | 0.665 | 0.668 | 0.995 | 101.73 | 148.41 | 141.60 |
| France | Developed | 0.652 | 0.653 | 1.000 | 106.83 | 131.80 | 131.50 |
| Czech Republic | Developed | 0.645 | 1.000 | 0.645 | 42.14 | 24.07 | 68.70 |
| Israel | Developed | 0.638 | 0.675 | 0.945 | 141.54 | 67.94 | 55.40 |
| Russian Federation | Developing | 0.626 | 1.000 | 0.626 | 115.61 | 58.04 | 58.90 |
| Brazil | Developing | 0.571 | 1.000 | 0.571 | 100.32 | 42.82 | 56.20 |
| Ireland | Developed | 0.534 | 0.565 | 0.946 | 55.46 | 52.61 | 88.90 |
| Chile | Developing | 0.477 | 0.818 | 0.583 | 129.57 | 27.07 | 23.00 |
| Belgium | Developed | 0.426 | 0.455 | 0.937 | 84.28 | 55.78 | 65.30 |
| Poland | Developed | 0.390 | 0.698 | 0.559 | 48.74 | 19.88 | 47.50 |
| Kazakhstan | Developing | 0.362 | 1.000 | 0.362 | 39.46 | 8.49 | 20.90 |
| Peru | Developing | 0.350 | 1.000 | 0.350 | 98.57 | 6.76 | 8.80 |
| Austria | Developed | 0.344 | 0.344 | 0.998 | 61.71 | 32.76 | 57.80 |
| Mexico | Developing | 0.280 | 1.000 | 0.280 | 38.78 | 11.27 | 31.00 |
| Ukraine | Developing | 0.269 | 1.000 | 0.269 | 78.31 | 1.41 | 2.60 |
| Colombia | Developing | 0.231 | 0.306 | 0.756 | 49.07 | 4.98 | 13.10 |
| Argentina | Developing | 0.165 | 1.000 | 0.165 | 33.03 | 3.14 | 9.90 |
| Panama | Developing | 0.152 | 1.000 | 0.152 | 31.42 | 0.59 | 2.00 |

When classical DEA model is solved by applying CCR and BCC formulation using the input and output values given in Table 3.3, the efficiency scores of overall efficiency, pure technical efficiency and scale efficiency is found as shown in Table 3.6. Overall efficiency is calculated assuming constant return to scale (CCR), pure technical efficiency is calculated assuming variable return to scale (BCC) and finally scale efficiency is calculated dividing overall efficiency score by pure technical efficiency score.

As seen in the literature survey, most of the empirical studies accept market capitalization as percent of GDP, value traded as percent of GDP and turnover ratio as the indicators of the stock market development. Therefore they are given in Table 3.6 to have an insight about the relation between efficiency and development of the stock markets.

Table 3.7 is derived from Table 3.6 as a descriptive summary and has some of the implications below:

- 16 countries are overall efficient, 28 countries are pure technical efficient and 17 countries are scale efficient.
- Average overall efficiency is 0.73, average pure technical efficiency is 0.89 and average scale efficiency is 0.73.
- While in overall efficiency 40 percent of the developed countries and 30 percent of the developing countries are found efficient, in pure technical efficiency developing countries have higher percentage values.
- Average market capitalization (percent of GDP) of overall efficient countries for both developed countries and developing countries is close to each other.
- Average value traded (percent of GDP) of overall efficient countries for developed countries is more than twice of developing countries.
- The biggest difference between overall efficient and overall inefficient countries in terms of average development indicators is in average value traded (percent of GDP).

**Table 3.7: Some statistics derived from Table 3.6**

| | Overall Efficiency | | | Pure Technical Efficiency | | | Scale Efficiency | | |
|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | A | B | C | A | B | C |
| Number of Efficient Countries | 10 | 6 | 16 | 12 | 16 | 28 | 11 | 6 | 17 |
| % of Efficient Countries | 40.00 | 30.00 | 35.56 | 48.00 | 80.00 | 62.22 | 44.00 | 30.00 | 37.78 |
| Average Efficiency | 0.80 | 0.64 | 0.73 | 0.84 | 0.95 | 0.89 | 0.92 | 0.54 | 0.73 |
| Standard Deviation of Efficiency | 0.22 | 0.33 | 0.28 | 0.20 | 0.16 | 0.19 | 0.14 | 0.28 | 0.29 |
| Average Market Capitalization (% of GDP) of Efficient Countries | 137.32 | 136.06 | 136.84 | 131.60 | 92.22 | 109.10 | 115.90 | 95.43 | 106.80 |
| Average Market Capitalization (% of GDP) of Inefficient Countries | 101.62 | 78.02 | 90.23 | 101.41 | 108.27 | 103.02 | 101.25 | 78.02 | 89.64 |
| Average Value Traded (% of GDP) of Efficient Countries | 226.14 | 95.72 | 177.24 | 199.23 | 46.08 | 111.71 | 152.31 | 44.69 | 46.51 |
| Average Value Traded (% of GDP) of Inefficient Countries | 103.09 | 22.82 | 64.34 | 109.01 | 39.12 | 92.57 | 101.04 | 22.82 | 61.93 |
| Average Turnover Ratio (%) of Efficient Countries | 183.09 | 93.97 | 149.67 | 164.65 | 51.03 | 99.73 | 136.94 | 46.51 | 97.64 |
| Average Turnover Ratio (%) of Inefficient Countries | 106.18 | 29.03 | 69.93 | 111.37 | 38.45 | 94.21 | 104.37 | 29.03 | 66.70 |

*A: Developed Countries; B: Developing Countries; C: Countries regarding criteria

Beside efficiency scores, DEA gives the target values for an inefficient DMU to be efficient. In Table 3.8 the target values calculated by CCR formulation for three output variables is given for all inefficient DMUs. For example, Norway to be efficient in year 2007, should increase market capitalization value to 813.11 value traded to 529.06 and turnover ratio to 189.98.

Another property of DEA is to give reference table. Reference table shows the reference countries for other countries with reference weights.

From the reference table for 2007 that is given in Table 3.9 it can be stated that the first three country which most referenced by other countries are Finland, Saudi Arabia and China.

**Table 3.8: Target values for outputs in 2007**

| | Value Traded (Billion USD) | | Market Capitalization (Billion USD) | | Turnover Ratio (%) | |
|---|---|---|---|---|---|---|
| Country | Original Value | Target Value | Original Value | Target Value | Original Value | Target Value |
| Argentina | 8.25 | 482.46 | 86.68 | 523.85 | 9.90 | 59.83 |
| Australia | 1,322.82 | 2,263.92 | 1,298.43 | 1,725.93 | 110.50 | 146.88 |
| Austria | 121.42 | 915.62 | 228.71 | 665.57 | 57.80 | 168.20 |
| Belgium | 255.69 | 1,227.54 | 386.36 | 906.39 | 65.30 | 153.19 |
| Brazil | 584.95 | 3,013.08 | 1,370.38 | 2,400.00 | 56.20 | 98.43 |
| Canada | 1,645.47 | 3,636.67 | 2,186.55 | 2,822.86 | 84.70 | 142.08 |
| Chile | 44.47 | 267.27 | 212.91 | 446.71 | 23.00 | 48.26 |
| Colombia | 10.34 | 270.34 | 101.96 | 441.12 | 13.10 | 56.68 |
| Czech Republic | 41.93 | 246.23 | 73.42 | 183.89 | 68.70 | 106.52 |
| France | 3,418.89 | 6,908.67 | 2,771.22 | 4,248.56 | 131.50 | 201.60 |
| Germany | 3,363.09 | 6,255.56 | 2,105.51 | 2,788.91 | 179.70 | 238.03 |
| Ireland | 136.62 | 538.45 | 144.03 | 376.98 | 88.90 | 166.50 |
| Israel | 113.46 | 322.48 | 236.36 | 370.33 | 55.40 | 86.80 |
| Japan | 6,497.19 | 12,481.26 | 4,453.47 | 6,698.23 | 141.60 | 212.97 |
| Kazakhstan | 8.90 | 65.81 | 41.38 | 114.34 | 20.90 | 57.75 |
| Kuwait | 120.70 | 276.24 | 188.05 | 195.66 | 76.20 | 79.28 |
| Malaysia | 150.00 | 205.77 | 325.66 | 389.54 | 53.50 | 63.99 |
| Mexico | 115.62 | 1,796.07 | 397.73 | 1,418.33 | 31.00 | 110.55 |
| Nigeria | 16.77 | 107.72 | 86.35 | 210.52 | 28.20 | 34.97 |
| Norway | 471.89 | 813.11 | 357.42 | 529.06 | 147.80 | 189.98 |
| Panama | 0.12 | 45.73 | 6.22 | 40.90 | 2.00 | 13.15 |
| Peru | 7.26 | 165.88 | 105.96 | 302.75 | 8.80 | 25.14 |
| Philippines | 29.25 | 68.11 | 103.22 | 149.25 | 34.10 | 42.95 |
| Poland | 84.57 | 701.98 | 207.32 | 531.34 | 47.50 | 121.74 |
| Russian Federation | 754.54 | 2,954.57 | 1,503.01 | 2,402.40 | 58.90 | 94.15 |
| Spain | 2,962.12 | 4,776.06 | 1,800.10 | 1,934.53 | 189.70 | 203.87 |
| Sweden | 968.83 | 1,192.57 | 612.50 | 753.95 | 147.40 | 181.44 |
| Thailand | 108.21 | 155.08 | 196.05 | 212.19 | 64.20 | 69.48 |
| Ukraine | 2.02 | 214.83 | 111.76 | 415.55 | 2.60 | 27.55 |

It is seen from Table 3.9 that the countries that should take Turkey as a reference for year 2007 are Poland (0.113), Brazil (0.021), Mexico (0.359), Philippines (0.028) and Thailand (0.133).

The reference tables are also used to calculate target values given in Table 3.8. When Norway is taken as an example again, from Table 3.9 the reference countries of Norway and their weights are Finland (0.556), Saudi Arabia (0.331) and Netherlands (0.153). If the value in market capitalization is taken; the target value is calculated as follows:

Target value of market capitalization = The value of market capitalization of Finland * 0.556 + The value of market capitalization of Saudi Arabia * 0.331 + The value of market capitalization of Netherlands * 0.153 = 543.34 * 0.556 + 679.84 * 0.331 +

1,803.44 * 0.153 = 813.91. It is slightly different from the target value shown in Table 3.8 because of rounding errors.

**Table 3.9: Reference table for 2007**

| No | Country | Countries Taken as References | | | | | No of being Reference |
|---|---|---|---|---|---|---|---|
| 1 | Australia | 23 (0.438) | 6 (0.295) | 29 (0.170) | | | 0 |
| 2 | Austria | 29 (0.008) | 6 (0.386) | 23 (0.200) | 19 (0.421) | | 0 |
| 3 | Belgium | 19 (0.160) | 6 (0.424) | 29 (0.048) | 23 (0.290) | | 0 |
| 4 | Canada | 29 (0.337) | 23 (0.569) | | | | 0 |
| 5 | Czech Republic | 6 (0.175) | 19 (0.194) | 9 (0.409) | | | 0 |
| 6 | Finland | 6 (1) | | | | | 18 |
| 7 | France | 6 (0.302) | 29 (0.462) | 24 (0.218) | 25 (0.021) | | 0 |
| 8 | Germany | 24 (0.141) | 12 (0.798) | 6 (0.051) | 25 (0.069) | | 0 |
| 9 | Hungary | 9 (1) | | | | | 3 |
| 10 | Ireland | 19 (0.209) | 6 (0.729) | | | | 0 |
| 11 | Israel | 6 (0.157) | 42 (0.213) | 20 (0.382) | | | 0 |
| 12 | Italy | 12 (1) | | | | | 3 |
| 13 | Japan | 25 (0.166) | 6 (0.270) | 24 (0.208) | 29 (0.398) | | 0 |
| 14 | Korea | 14 (1) | | | | | 2 |
| 15 | Kuwait | 6 (0.369) | 23 (0.028) | 20 (0.066) | | | 0 |
| 16 | Netherlands | 16 (1) | | | | | 1 |
| 17 | Norway | 19 (0.331) | 6 (0.576) | 16 (0.153) | | | 0 |
| 18 | Poland | 29 (0.025) | 19 (0.582) | 14 (0.040) | 44 (0.113) | | 0 |
| 19 | Saudi Arabia | 19 (1) | | | | | 14 |
| 20 | Singapore | 20 (1) | | | | | 5 |
| 21 | Spain | 24 (0.412) | 14 (0.124) | 19 (0.352) | 6 (0.054) | 12 (0.004) | 0 |
| 22 | Sweden | 29 (0.039) | 19 (0.012) | 6 (0.861) | 23 (0.052) | 24 (0.031) | 0 |
| 23 | Switzerland | 23 (1) | | | | | 9 |
| 24 | United Kingdom | 24 (1) | | | | | 5 |
| 25 | United States | 25 (1) | | | | | 3 |
| 26 | Argentina | 42 (0.296) | 6 (0.034) | 19 (0.203) | 29 (0.026) | | 0 |
| 27 | Brazil | 6 (0.113) | 19 (0.048) | 29 (0.374) | 44 (0.021) | | 0 |
| 28 | Chile | 6 (0.011) | 20 (0.172) | 42 (0.458) | | | 0 |
| 29 | China | 29 (1) | | | | | 14 |
| 30 | Colombia | 42 (0.388) | 29 (0.001) | 19 (0.111) | 31 (0.378) | | 0 |
| 31 | Egypt | 31 (1) | | | | | 6 |
| 32 | India | 32 (1) | | | | | 2 |
| 33 | Indonesia | 33 (1) | | | | | 1 |
| 34 | Kazakhstan | 42 (0.087) | 9 (0.436) | 31 (0.148) | | | 0 |
| 35 | Malaysia | 42 (0.416) | 9 (0.301) | 31 (0.175) | 19 (0.007) | | 0 |
| 36 | Mexico | 44 (0.359) | 29 (0.199) | 6 (0.104) | 12 (0.034) | | 0 |
| 37 | Nigeria | 32 (0.066) | 31 (0.645) | | | | 0 |
| 38 | Panama | 20 (0.104) | 23 (0.003) | | | | 0 |
| 39 | Peru | 6 (0.02) | 42 (0.346) | 20 (0.021) | | | 0 |
| 40 | Philippines | 32 (0.014) | 44 (0.028) | 31 (0.832) | | | 0 |
| 41 | Russian Federation | 42 (0.121) | 23 (0.114) | 19 (0.060) | 29 (0.341) | | 0 |
| 42 | South Africa | 42 (1) | | | | | 9 |
| 43 | Thailand | 33 (0.045) | 19 (0.069) | 44 (0.133) | 29 (0.003) | 31 (0.813) | 0 |
| 44 | Turkey | 44 (1) | | | | | 5 |
| 45 | Ukraine | 42 (0.495) | 23 (0.002) | | | | 0 |

### 3.5.2 Results and Evaluation of 2008

In order to solve conventional DEA for year 2008, the data in Table 3.10 is employed. Here the first three columns include the data for output variables and the last seven columns include the data for input variables of 45 countries in alphabetical order.

As seen in Table 3.11 the average of value traded in terms of billion USD is 2,725.59 for developed countries, 452.65 for developing countries and 1,715.39 for 45 countries. The average of market capitalization in terms of billion USD is 1,037.92 for developed countries, 311.65 for developing countries and 715.13 for 45 countries. Similarly, the average of value turnover ratio is 137.02 for developed countries, 47.24 for developing countries and 97.64 for 45 countries.

When input variables is considered, the average values of 45 countries are 4.56 for institutional environment; 4.70 for business environment; 4.77 for financial stability; 3.76 for banking financial services; 2.70 for non-banking financial services; 1,229.82 billion USD for GDP and finally 26,369 USD for GDP per capita. There is a difference in these values depending on the stage of development as in output variables.

From Table 3.10 it can be calculated that in 2008, about 47 percent of all value traded in the world and 36.5 percent of world's market capitalization value belongs to United States. The selected 15 countries that have the highest values in value traded have 94 percent share in value traded and 88 percent share in market capitalization (See Figure 3.2). These 15 countries are United States, United Kingdom, China, Japan, France, Germany, Spain, Italy, Korea, Netherlands, Switzerland, Canada, Australia, India and Brazil. The only difference from 2007 is that Brazil enters the list instead of Sweden. Among 15 countries; United States, United Kingdom, China, Japan and France together have 74.5 percent share in value traded and 65.5 percent share in market capitalization. All these statistics similar to the statistics of year 2007 but there is a slight increase in share of the market capitalization values. As only considered the value traded and market capitalization; USA has the highest values among developed countries, China has the highest values among developing countries, Hungary has the lowest values among developed countries and Panama has lowest values among developing countries.

**Table 3.10: Input and output values for 2008**

| Country | Value Traded (Billion USD) | Market Capitalization (Billion USD) | Turnover Ratio (%) | Institutional Environment | Business Environment | Financial Stability | Banking Financial Services | Non-Banking Financial Services | GDP (Billion USD) | GDP per Capita (USD) |
|---|---|---|---|---|---|---|---|---|---|---|
| Argentina | 13.42 | 52.31 | 19.31 | 3.23 | 3.81 | 3.68 | 2.78 | 2.28 | 326.58 | 8,189 |
| Australia | 1,017.71 | 675.62 | 103.06 | 5.56 | 5.68 | 5.48 | 5.01 | 4.36 | 1,039.42 | 48,499 |
| Austria | 104.52 | 72.30 | 68.98 | 5.71 | 5.29 | 4.81 | 4.24 | 1.87 | 414.67 | 49,739 |
| Belgium | 211.78 | 167.45 | 76.09 | 5.54 | 5.08 | 4.66 | 4.79 | 2.48 | 505.37 | 47,194 |
| Brazil | 727.79 | 589.38 | 74.27 | 3.64 | 3.63 | 5.13 | 3.46 | 3.20 | 1,637.92 | 8,532 |
| Canada | 1,770.63 | 1,002.22 | 123.72 | 5.62 | 5.94 | 5.57 | 4.83 | 3.99 | 1,499.11 | 45,003 |
| Chile | 36.56 | 132.43 | 21.17 | 4.29 | 4.84 | 5.62 | 3.43 | 1.87 | 170.85 | 10,167 |
| China | 5,470.53 | 2,793.61 | 121.30 | 4.07 | 4.09 | 4.83 | 4.77 | 3.31 | 4,521.83 | 3,414 |
| Colombia | 12.48 | 87.03 | 13.21 | 3.30 | 4.11 | 4.80 | 2.57 | 1.65 | 242.58 | 5,389 |
| Czech Republic | 43.03 | 48.85 | 70.39 | 4.31 | 4.19 | 5.08 | 3.85 | 1.41 | 216.08 | 20,729 |
| Egypt | 69.64 | 85.89 | 61.85 | 3.87 | 3.70 | 4.27 | 3.09 | 2.16 | 162.84 | 1,997 |
| Finland | 390.41 | 154.37 | 155.12 | 5.67 | 5.88 | 5.27 | 3.78 | 2.26 | 270.48 | 50,905 |
| France | 3,265.49 | 1,492.33 | 152.45 | 5.35 | 5.09 | 5.27 | 4.05 | 3.98 | 2,854.23 | 44,471 |
| Germany | 3,105.29 | 1,107.96 | 191.54 | 5.66 | 5.60 | 5.34 | 4.23 | 3.52 | 3,634.53 | 44,264 |
| Hungary | 30.80 | 18.58 | 93.01 | 4.41 | 4.68 | 3.70 | 2.37 | 1.48 | 154.67 | 15,408 |
| India | 1,049.75 | 645.48 | 85.19 | 3.38 | 3.51 | 4.23 | 3.12 | 3.12 | 1,214.21 | 1,065 |
| Indonesia | 110.68 | 98.76 | 71.30 | 3.54 | 3.26 | 4.44 | 2.63 | 1.96 | 510.50 | 2,245 |
| Ireland | 37.21 | 49.40 | 85.04 | 5.61 | 5.48 | 4.48 | 4.98 | 3.21 | 266.33 | 60,178 |
| Israel | 109.16 | 134.46 | 58.87 | 4.68 | 4.60 | 4.76 | 3.97 | 1.89 | 202.10 | 27,652 |
| Italy | 668.94 | 520.86 | 284.24 | 4.22 | 4.94 | 4.44 | 4.01 | 2.82 | 2,296.63 | 38,385 |
| Japan | 5,879.44 | 3,220.49 | 153.23 | 5.43 | 5.45 | 4.57 | 5.15 | 4.03 | 4,886.97 | 38,268 |
| Kazakhstan | 3.45 | 31.08 | 11.73 | 3.39 | 4.05 | 3.50 | 2.52 | 2.81 | 133.44 | 8,514 |
| Korea | 1,466.00 | 494.63 | 181.18 | 4.26 | 5.35 | 4.73 | 4.16 | 3.02 | 931.40 | 19,162 |
| Kuwait | 122.74 | 107.17 | 83.16 | 3.94 | 4.51 | 5.49 | 3.79 | 1.13 | 148.02 | 54,260 |
| Malaysia | 85.21 | 187.07 | 33.24 | 4.86 | 4.49 | 5.14 | 4.66 | 2.44 | 221.83 | 8,212 |
| Mexico | 108.20 | 232.58 | 34.33 | 3.59 | 3.90 | 5.13 | 2.37 | 2.01 | 1,089.88 | 10,248 |
| Netherlands | 1,143.04 | 387.91 | 169.18 | 5.82 | 5.84 | 4.91 | 4.90 | 4.10 | 872.87 | 53,076 |
| Nigeria | 19.95 | 49.80 | 29.30 | 3.83 | 2.95 | 4.71 | 2.45 | 1.26 | 207.12 | 1,370 |
| Norway | 368.26 | 125.92 | 152.17 | 5.89 | 5.98 | 5.73 | 4.34 | 2.26 | 450.92 | 94,568 |
| Panama | 0.26 | 6.57 | 4.01 | 4.51 | 4.09 | 4.57 | 4.05 | 1.59 | 23.18 | 6,821 |
| Peru | 5.11 | 55.63 | 6.33 | 3.70 | 3.95 | 4.90 | 2.77 | 1.60 | 129.11 | 4,477 |
| Philippines | 17.21 | 52.10 | 22.16 | 3.62 | 3.36 | 4.12 | 2.63 | 1.81 | 166.60 | 1,844 |
| Poland | 67.95 | 90.23 | 45.68 | 3.90 | 4.34 | 4.78 | 3.17 | 1.73 | 528.32 | 13,857 |
| Russian Federation | 562.23 | 397.18 | 75.02 | 3.01 | 4.21 | 4.50 | 1.80 | 4.13 | 1,666.95 | 11,743 |
| Saudi Arabia | 524.72 | 246.34 | 137.82 | 4.60 | 4.88 | 5.60 | 3.58 | 2.03 | 475.09 | 19,152 |
| Singapore | 270.90 | 180.02 | 101.34 | 6.17 | 6.05 | 5.61 | 4.68 | 3.37 | 193.33 | 39,950 |
| South Africa | 401.49 | 491.28 | 60.61 | 4.41 | 4.15 | 4.67 | 3.75 | 2.13 | 276.45 | 5,666 |
| Spain | 2,440.24 | 946.11 | 177.57 | 5.12 | 4.92 | 4.66 | 5.07 | 3.25 | 1,594.47 | 35,000 |
| Sweden | 641.75 | 252.54 | 157.02 | 5.87 | 5.93 | 5.07 | 4.61 | 2.67 | 487.58 | 52,884 |
| Switzerland | 1,505.27 | 862.66 | 145.59 | 5.70 | 5.84 | 5.66 | 4.56 | 3.19 | 502.45 | 65,699 |
| Thailand | 116.77 | 102.59 | 78.20 | 4.08 | 4.43 | 4.57 | 3.49 | 1.58 | 272.43 | 4,043 |
| Turkey | 239.71 | 117.93 | 118.52 | 3.50 | 4.37 | 3.79 | 2.96 | 1.83 | 730.34 | 9,881 |
| Ukraine | 2.54 | 24.36 | 3.73 | 3.08 | 3.73 | 3.19 | 2.38 | 2.39 | 180.36 | 3,899 |
| United Kingdom | 6,486.96 | 1,851.95 | 226.85 | 5.54 | 5.63 | 4.57 | 5.32 | 6.36 | 2,662.65 | 43,361 |
| United States | 36,467.40 | 11,737.60 | 232.26 | 5.63 | 5.70 | 4.56 | 4.21 | 5.93 | 14,369.10 | 47,209 |

**Source: Worldbank World Development Indicators and WEF Financial Development Report 2009**

**Table 3.11: Some descriptive statistics of variables for 2008**

| | Value Traded (Billion USD) | Market Capitalization (Billion USD) | Turnover Ratio (%) | Institutional Environment | Business Environment | Financial Stability | Banking Financial Services | Non-Banking Financial Services | GDP (Billion USD) | GDP per Capita (USD) |
|---|---|---|---|---|---|---|---|---|---|---|
| Average - Developed | 2,725.59 | 1,037.92 | 137.02 | 5.21 | 5.31 | 4.99 | 4.31 | 3.05 | 1,658.27 | 42,755 |
| Average - Developing | 452.65 | 311.65 | 47.24 | 3.75 | 3.93 | 4.49 | 3.08 | 2.26 | 694.25 | 5,886 |
| Average - Total | 1,715.39 | 715.13 | 97.12 | 4.56 | 4.70 | 4.77 | 3.76 | 2.70 | 1,229.82 | 26,369 |
| Standard Deviation - Developed | 7,241.49 | 2,346.40 | 59.62 | 0.69 | 0.56 | 0.50 | 0.68 | 1.31 | 2,920.96 | 17,762 |
| Standard Deviation - Developing | 1,214.98 | 615.30 | 37.04 | 0.50 | 0.45 | 0.61 | 0.77 | 0.73 | 1,033.24 | 3,381 |
| Standard Deviation - Total | 5,526.77 | 1,816.52 | 67.58 | 0.95 | 0.86 | 0.60 | 0.94 | 1.15 | 2,312.90 | 22,810 |
| Minimum - Developed | 30.80 | 18.58 | 45.68 | 3.90 | 4.19 | 3.70 | 2.37 | 1.13 | 148.02 | 13,857 |
| Minimum - Developing | 0.26 | 6.57 | 3.73 | 3.01 | 2.95 | 3.19 | 1.80 | 1.26 | 23.18 | 1,065 |
| Maximum - Developed | 36,467.40 | 11,737.60 | 284.24 | 6.17 | 6.05 | 5.73 | 5.32 | 6.36 | 14,369.10 | 94,568 |
| Maximum - Developing | 5,470.53 | 2,793.61 | 121.30 | 4.86 | 4.84 | 5.62 | 4.77 | 4.13 | 4,521.83 | 11,743 |

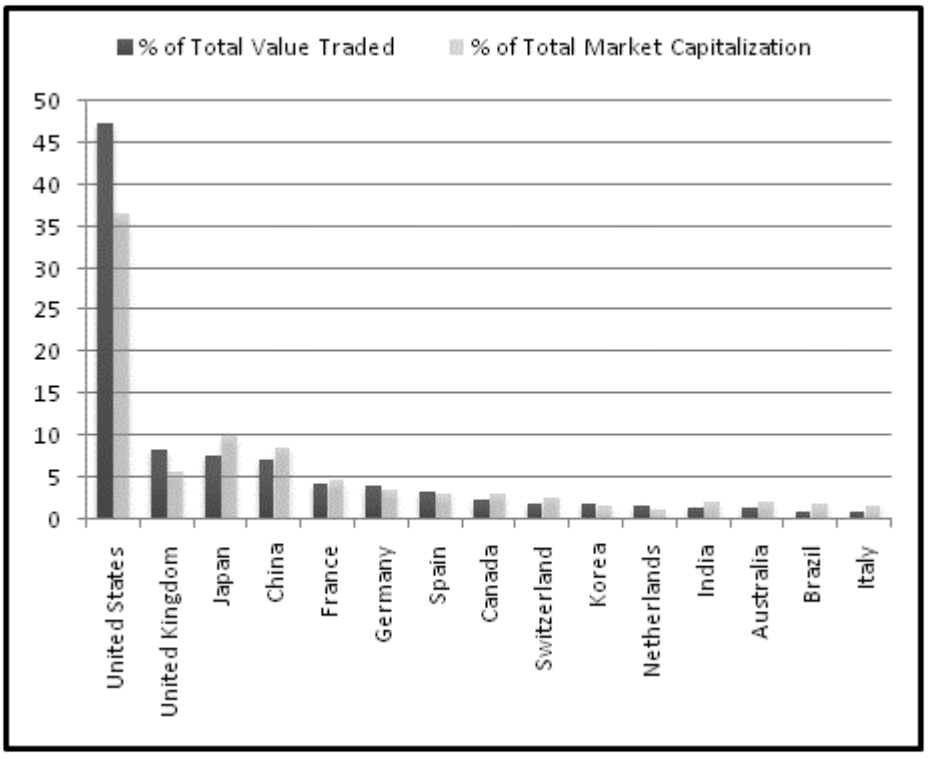


**Figure 3.2: The biggest 15 markets in 2008**

When the correlations between variables for year 2008 given in Table 3.12 are inspected some implications as follows:

- Value traded and market capitalization is highly correlated whereas turnover ratio has a medium and nearly same correlation with the other two output variables as in year 2007.
- Value traded and market capitalization is highly correlated with GDP but not with GDP per capita.
- GDP per capita has medium or high correlation with the other input variables except GDP.
- GDP per capita is highly correlated with institutional environment, business environment.
- Value traded and market capitalization has low correlation with institutional environment, business environment, financial stability and banking financial services.

**Table 3.12: Correlations of variables for 2008**

| | Value Traded (Billion USD) | Market Capitalization (Billion USD) | Turnover Ratio (%) | Institutional Environment | Business Environment | Financial Stability | Banking Financial Services | Non-Banking Financial Services | GDP (Billion USD) | GDP per Capita (USD) |
|---|---|---|---|---|---|---|---|---|---|---|
| Value Traded (Billion USD) | 1.00 | | | | | | | | | |
| Market Capitalization (Billion USD) | 0.99 | 1.00 | | | | | | | | |
| Turnover Ratio (%) | 0.45 | 0.46 | 1.00 | | | | | | | |
| Institutional Environment | 0.26 | 0.26 | 0.57 | 1.00 | | | | | | |
| Business Environment | 0.26 | 0.26 | 0.67 | 0.89 | 1.00 | | | | | |
| Financial Stability | -0.02 | 0.00 | 0.25 | 0.55 | 0.51 | 1.00 | | | | |
| Banking Financial Services | 0.22 | 0.26 | 0.58 | 0.84 | 0.75 | 0.48 | 1.00 | | | |
| Non-Banking Financial Services | 0.60 | 0.62 | 0.63 | 0.46 | 0.52 | 0.09 | 0.52 | 1.00 | | |
| GDP (Billion USD) | 0.96 | 0.98 | 0.53 | 0.24 | 0.26 | 0.00 | 0.25 | 0.65 | 1.00 | |
| GDP per Capita (USD) | 0.20 | 0.19 | 0.60 | 0.83 | 0.85 | 0.51 | 0.67 | 0.39 | 0.19 | 1.00 |

**Table 3.13: Efficiency scores for 2008**

| Country | Stage of Development | Overall Efficiency | Pure Technical Efficiency | Scale Efficiency | Market Capitalization (% of GDP) | Value Traded (% of GDP) | Turnover Ratio (%) |
|---|---|---|---|---|---|---|---|
| China | Developing | 1.000 | 1.000 | 1.000 | 61.63 | 120.69 | 121.30 |
| Egypt | Developing | 1.000 | 1.000 | 1.000 | 52.75 | 42.77 | 61.85 |
| Finland | Developed | 1.000 | 1.000 | 1.000 | 57.22 | 144.71 | 155.12 |
| Hungary | Developed | 1.000 | 1.000 | 1.000 | 12.01 | 19.91 | 93.01 |
| India | Developing | 1.000 | 1.000 | 1.000 | 53.16 | 86.46 | 85.19 |
| Indonesia | Developing | 1.000 | 1.000 | 1.000 | 19.35 | 21.68 | 71.30 |
| Italy | Developed | 1.000 | 1.000 | 1.000 | 22.68 | 29.13 | 284.24 |
| Korea | Developed | 1.000 | 1.000 | 1.000 | 53.11 | 157.40 | 181.18 |
| Kuwait | Developed | 1.000 | 1.000 | 1.000 | 72.40 | 82.92 | 83.16 |
| Saudi Arabia | Developed | 1.000 | 1.000 | 1.000 | 51.85 | 110.44 | 137.82 |
| Singapore | Developed | 1.000 | 1.000 | 1.000 | 93.12 | 140.12 | 101.34 |
| South Africa | Developing | 1.000 | 1.000 | 1.000 | 177.71 | 145.23 | 60.61 |
| Switzerland | Developed | 1.000 | 1.000 | 1.000 | 172.44 | 300.90 | 145.59 |
| Thailand | Developing | 1.000 | 1.000 | 1.000 | 37.66 | 42.86 | 78.20 |
| Turkey | Developing | 1.000 | 1.000 | 1.000 | 16.15 | 32.82 | 118.52 |
| United Kingdom | Developed | 1.000 | 1.000 | 1.000 | 69.55 | 243.63 | 226.85 |
| United States | Developed | 1.000 | 1.000 | 1.000 | 81.69 | 253.79 | 232.26 |
| Sweden | Developed | 0.962 | 0.963 | 0.999 | 51.80 | 131.62 | 157.02 |
| Spain | Developed | 0.958 | 1.000 | 0.958 | 59.34 | 153.04 | 177.57 |
| Norway | Developed | 0.926 | 0.930 | 0.996 | 27.93 | 81.67 | 152.17 |
| Netherlands | Developed | 0.922 | 0.930 | 0.991 | 44.44 | 130.95 | 169.18 |
| Japan | Developed | 0.822 | 0.830 | 0.990 | 65.90 | 120.31 | 153.23 |
| France | Developed | 0.756 | 0.773 | 0.978 | 52.28 | 114.41 | 152.45 |
| Russian Federation | Developing | 0.754 | 1.000 | 0.754 | 23.82 | 33.71 | 75.02 |
| Czech Republic | Developed | 0.744 | 0.887 | 0.840 | 22.61 | 19.92 | 70.39 |
| Canada | Developed | 0.731 | 0.745 | 0.981 | 66.85 | 118.11 | 123.72 |
| Nigeria | Developing | 0.710 | 1.000 | 0.710 | 24.05 | 9.63 | 29.30 |
| Germany | Developed | 0.669 | 0.687 | 0.974 | 30.31 | 84.94 | 191.54 |
| Israel | Developed | 0.649 | 0.673 | 0.963 | 66.53 | 54.01 | 58.87 |
| Australia | Developed | 0.647 | 0.649 | 0.998 | 65.00 | 97.91 | 103.06 |
| Brazil | Developing | 0.642 | 0.705 | 0.911 | 35.97 | 44.42 | 74.27 |
| Ireland | Developed | 0.632 | 0.664 | 0.952 | 18.55 | 13.97 | 85.04 |
| Malaysia | Developing | 0.544 | 0.550 | 0.988 | 84.58 | 38.53 | 33.24 |
| Belgium | Developed | 0.512 | 0.553 | 0.925 | 33.16 | 41.95 | 76.09 |
| Austria | Developed | 0.499 | 0.506 | 0.985 | 17.51 | 25.31 | 68.98 |
| Chile | Developing | 0.465 | 0.583 | 0.797 | 77.51 | 21.40 | 21.17 |
| Philippines | Developing | 0.450 | 1.000 | 0.450 | 31.11 | 10.28 | 22.16 |
| Poland | Developed | 0.397 | 0.461 | 0.862 | 17.08 | 12.86 | 45.68 |
| Mexico | Developing | 0.343 | 0.810 | 0.423 | 21.34 | 9.93 | 34.33 |
| Panama | Developing | 0.324 | 1.000 | 0.324 | 28.33 | 1.10 | 4.01 |
| Colombia | Developing | 0.258 | 1.000 | 0.258 | 35.77 | 5.13 | 13.21 |
| Peru | Developing | 0.242 | 1.000 | 0.242 | 43.08 | 3.96 | 6.33 |
| Argentina | Developing | 0.238 | 0.620 | 0.383 | 15.93 | 4.09 | 19.31 |
| Kazakhstan | Developing | 0.223 | 1.000 | 0.223 | 23.29 | 2.58 | 11.73 |
| Ukraine | Developing | 0.087 | 1.000 | 0.087 | 13.53 | 1.41 | 3.73 |

After classical DEA model is solved by applying CCR and BCC formulation using the input and output data in Table 3.10 the efficiency scores of overall efficiency, pure technical efficiency and scale efficiency is calculated as shown in Table 3.13.

Table 3.14 is derived from Table 3.13 as a descriptive summary and has some of the implications below:

- 17 countries are overall efficient, 26 countries are pure technical efficient and 17 countries are scale efficient. This implies that scale efficiency determining factor for overall efficiency.
- Number of pure technical efficient developing countries is higher than overall efficient developing countries as in year 2007.
- Average overall efficiency is 0.74, average pure technical efficiency is 0.88 and average scale efficiency is 0.84.
- Average values of the stock market development indicators of overall efficient countries is about half of the year 2007.

**Table 3.14: Some statistics derived from Table 3.13**

| | Overall Efficiency | | | Pure Technical Efficiency | | | Scale Efficiency | | |
|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | A | B | C | A | B | C |
| Number of Efficient Countries | 10 | 7 | 17 | 11 | 15 | 26 | 10 | 7 | 17 |
| % of Efficient Countries | 40.00 | 35.00 | 37.78 | 44.00 | 75.00 | 57.78 | 40.00 | 35.00 | 37.78 |
| Average Efficiency | 0.83 | 0.61 | 0.74 | 0.85 | 0.91 | 0.88 | 0.98 | 0.68 | 0.84 |
| Standard Deviation of Efficiency | 0.19 | 0.33 | 0.28 | 0.18 | 0.16 | 0.17 | 0.04 | 0.34 | 0.27 |
| Average Market Capitalization (% of GDP) of Efficient Countries | 68.61 | 59.77 | 64.97 | 67.76 | 42.76 | 53.34 | 68.61 | 59.77 | 64.97 |
| Average Market Capitalization (% of GDP) of Inefficient Countries | 42.62 | 35.25 | 39.20 | 41.42 | 47.07 | 42.91 | 42.62 | 35.25 | 39.20 |
| Average Value Traded (% of GDP) of Efficient Countries | 148.29 | 70.36 | 116.20 | 148.73 | 37.35 | 84.47 | 148.29 | 70.36 | 116.20 |
| Average Value Traded (% of GDP) of Inefficient Countries | 80.07 | 14.32 | 49.54 | 74.85 | 23.67 | 61.38 | 80.07 | 14.32 | 49.54 |
| Average Turnover Ratio (%) of Efficient Countries | 164.06 | 85.28 | 131.62 | 165.29 | 50.83 | 99.25 | 164.06 | 85.28 | 131.62 |
| Average Turnover Ratio (%) of Inefficient Countries | 119.00 | 26.75 | 76.17 | 114.82 | 36.47 | 94.20 | 119.00 | 26.75 | 76.17 |

*A: Developed Countries; B: Developing Countries; C: Countries regarding criteria

The target values calculated by CCR model for three output variables for all inefficient DMUs given in Table 3.15 shows the value of outputs for those DMUs to be efficient in year 2008.

From the reference table for 2008 that is given in Table 3.16 it can be state that the first three country which is most referenced by other countries are Italy, Korea and South Africa.

Although Turkey was found overall efficient in year 2008 there is no other country that takes Turkey as reference.

**Table 3.15: Target values for outputs in 2008**

| | Value Traded (Billion USD) | | Market Capitalization (Billion USD) | | Turnover Ratio (%) | |
|---|---|---|---|---|---|---|
| Country | Original Value | Target Value | Original Value | Target Value | Original Value | Target Value |
| Argentina | 13.42 | 416.63 | 52.31 | 220.21 | 19.31 | 81.29 |
| Australia | 1,017.71 | 2,468.10 | 675.62 | 1,044.33 | 103.06 | 159.30 |
| Austria | 104.52 | 323.87 | 72.30 | 166.09 | 68.98 | 138.33 |
| Belgium | 211.78 | 613.19 | 167.45 | 327.20 | 76.09 | 148.68 |
| Brazil | 727.79 | 1,872.45 | 589.38 | 917.66 | 74.27 | 115.64 |
| Canada | 1,770.63 | 3,521.83 | 1,002.22 | 1,370.71 | 123.72 | 169.21 |
| Chile | 36.56 | 287.12 | 132.43 | 284.76 | 21.17 | 45.52 |
| Colombia | 12.48 | 370.41 | 87.03 | 336.91 | 13.21 | 51.14 |
| Czech Republic | 43.03 | 137.14 | 48.85 | 65.63 | 70.39 | 94.56 |
| France | 3,265.49 | 5,459.80 | 1,492.33 | 1,974.67 | 152.45 | 201.72 |
| Germany | 3,105.29 | 4,639.22 | 1,107.96 | 1,753.18 | 191.54 | 286.16 |
| Ireland | 37.21 | 337.87 | 49.40 | 138.11 | 85.04 | 134.57 |
| Israel | 109.16 | 298.54 | 134.46 | 207.25 | 58.87 | 90.74 |
| Japan | 5,879.44 | 11,953.03 | 3,220.49 | 3,917.37 | 153.23 | 186.39 |
| Kazakhstan | 3.45 | 124.40 | 31.08 | 139.44 | 11.73 | 52.63 |
| Malaysia | 85.21 | 289.42 | 187.07 | 344.12 | 33.24 | 61.15 |
| Mexico | 108.20 | 1,880.86 | 232.58 | 678.94 | 34.33 | 100.21 |
| Netherlands | 1,143.04 | 1,240.01 | 387.91 | 435.66 | 169.18 | 183.53 |
| Nigeria | 19.95 | 78.72 | 49.80 | 70.11 | 29.30 | 41.25 |
| Norway | 368.26 | 397.74 | 125.92 | 191.65 | 152.17 | 164.35 |
| Panama | 0.26 | 28.91 | 6.57 | 20.29 | 4.01 | 12.39 |
| Peru | 5.11 | 187.51 | 55.63 | 229.44 | 6.33 | 28.31 |
| Philippines | 17.21 | 108.78 | 52.10 | 115.87 | 22.16 | 49.29 |
| Poland | 67.95 | 503.81 | 90.23 | 227.01 | 45.68 | 114.92 |
| Russian Federation | 562.23 | 1,190.19 | 397.18 | 526.86 | 75.02 | 99.52 |
| Spain | 2,440.24 | 2,700.97 | 946.11 | 987.70 | 177.57 | 185.38 |
| Sweden | 641.75 | 728.18 | 252.54 | 262.53 | 157.02 | 163.23 |
| Ukraine | 2.54 | 245.95 | 24.36 | 278.72 | 3.73 | 42.68 |

## Table 3.16: Reference table for 2008

| No | Country | Countries Taken as References | | | | | No of being Reference |
|---|---|---|---|---|---|---|---|
| 1 | Australia | 23 (0.617) | 42 (0.025) | 25 (0.028) | 14 (0.339) | | 0 |
| 2 | Austria | 6 (0.593) | 12 (0.096) | 15 (0.229) | | | 0 |
| 3 | Belgium | 23 (0.214) | 12 (0.107) | 6 (0.561) | | | 0 |
| 4 | Canada | 23 (0.514) | 25 (0.058) | 42 (0.092) | 14 (0.416) | | 0 |
| 5 | Czech Republic | 19 (0.038) | 6 (0.215) | 9 (0.523) | 12 (0.026) | | 0 |
| 6 | Finland | 6 (1) | | | | | 8 |
| 7 | France | 23 (0.329) | 24 (0.057) | 25 (0.116) | 12 (0.341) | 14 (0.093) | 0 |
| 8 | Germany | 12 (0.886) | 25 (0.103) | 24 (0.046) | | | 0 |
| 9 | Hungary | 9 (1) | | | | | 4 |
| 10 | Ireland | 6 (0.835) | 12 (0.018) | | | | 0 |
| 11 | Israel | 23 (0.010) | 6 (0.393) | 42 (0.229) | 20 (0.144) | | 0 |
| 12 | Italy | 12 (1) | | | | | 15 |
| 13 | Japan | 23 (0.197) | 24 (0.094) | 25 (0.289) | 12 (0.034) | 14 (0.329) | 0 |
| 14 | Korea | 14 (1) | | | | | 13 |
| 15 | Kuwait | 15 (1) | | | | | 3 |
| 16 | Netherlands | 12 (0.043) | 6 (0.202) | 14 (0.772) | | | 0 |
| 17 | Norway | 25 (0.001) | 15 (0.202) | 6 (0.787) | 12 (0.090) | | 0 |
| 18 | Poland | 19 (0.406) | 14 (0.157) | 43 (0.161) | 12 (0.063) | | 0 |
| 19 | Saudi Arabia | 19 (1) | | | | | 3 |
| 20 | Singapore | 20 (1) | | | | | 5 |
| 21 | Spain | 23 (0.210) | 24 (0.133) | 25 (0.025) | 12 (0.205) | 14 (0.335) | 0 |
| 22 | Sweden | 12 (0.005) | 6 (0.675) | 14 (0.314) | | | 0 |
| 23 | Switzerland | 23 (1) | | | | | 9 |
| 24 | United Kingdom | 24 (1) | | | | | 4 |
| 25 | United States | 25 (1) | | | | | 10 |
| 26 | Argentina | 42 (0.140) | 31 (0.264) | 14 (0.164) | 19 (0.195) | | 0 |
| 27 | Brazil | 32 (0.273) | 14 (0.302) | 29 (0.204) | 12 (0.046) | | 0 |
| 28 | Chile | 20 (0.106) | 42 (0.450) | 23 (0.052) | | | 0 |
| 29 | China | 29 (1) | | | | | 1 |
| 30 | Colombia | 42 (0.588) | 25 (0.001) | 14 (0.079) | 23 (0.008) | | 0 |
| 31 | Egypt | 31 (1) | | | | | 4 |
| 32 | India | 32 (1) | | | | | 5 |
| 33 | Indonesia | 33 (1) | | | | | 1 |
| 34 | Kazakhstan | 42 (0.256) | 9 (0.356) | 20 (0.040) | | | 0 |
| 35 | Malaysia | 9 (0.167) | 42 (0.678) | 20 (0.045) | | | 0 |
| 36 | Mexico | 32 (0.173) | 25 (0.031) | 14 (0.371) | 12 (0.039) | | 0 |
| 37 | Nigeria | 32 (0.025) | 33 (0.216) | 43 (0.061) | 31 (0.307) | | 0 |
| 38 | Panama | 15 (0.042) | 20 (0.088) | | | | 0 |
| 39 | Peru | 42 (0.467) | | | | | 0 |
| 40 | Philippines | 42 (0.081) | 32 (0.028) | 31 (0.680) | | | 0 |
| 41 | Russian Federation | 32 (0.196) | 25 (0.022) | 12 (0.273) | | | 0 |
| 42 | South Africa | 42 (1) | | | | | 11 |
| 43 | Thailand | 43 (1) | | | | | 2 |
| 44 | Turkey | 44 (1) | | | | | 0 |
| 45 | Ukraine | 42 (0.536) | 31 (0.078) | 14 (0.017) | 9 (0.025) | | 0 |

### 3.5.3 Results and Evaluation of 2009

The data in Table 3.18 is used to solve classical DEA for year 2009. In Table 3.18 the first three columns includes the data for output variables and the last seven columns includes the data for input variables of 45 countries in alphabetical order.

As seen in Table 3.17 the average of value traded in terms of billion USD is 2,631.13 for developed countries, 624.94 for developing countries and 1,739.49 for 45 countries. The average of market capitalization in terms of billion USD is 1,349.77 for developed countries, 540.32 for developing countries and 990.01 for 45 countries. Similarly, the average of value turnover ratio is 108.23 for developed countries, 56.97 for developing countries and 85.45 for 45 countries.

When input variables is considered, the average values of 45 countries are 4.58 for institutional environment; 4.70 for business environment; 4.54 for financial stability; 3.81 for banking financial services; 2.80 for non-banking financial services; 1,116.22 billion USD for GDP and finally 23,298 USD for GDP per capita. There is a difference in these values depending on the stage of development as in output variables.

From Table 3.17 it can be calculated that in 2009, about 60 percent of all value traded in the world and 36.5 percent of world's market capitalization value belongs to United States. It was 47 percent for value traded in year 2008. The selected 15 countries that have the highest values in value traded have 94 percent share in value traded and 88 percent share in market capitalization. These 15 countries are United States, China, Japan, United Kingdom, Spain, Korea, France, Germany, Canada, India, Switzerland, Australia, Russian Federation, Brazil and Netherlands (See Figure 3.3).

As compared by the selected 15 countries that have the highest values in value traded of year 2008, it is seen that the share and rank of developing countries is increased.

Among 15 countries United States, China, Japan, United Kingdom and Spain together have 83 percent share in value traded and 62 percent share in market capitalization. In these statistics compared to the statistics of year 2008, there is a serious increase in share of the value traded value of United States and China.

**Table 3.17: Some descriptive statistics of variables**

| | Value Traded (Billion USD) | Market Capitalization (Billion USD) | Turnover Ratio (%) | Institutional Environment | Business Environment | Financial Stability | Banking Financial Services | Non-Banking Financial Services | GDP (Billion USD) | GDP per Capita (USD) |
|---|---|---|---|---|---|---|---|---|---|---|
| Average - Developed | 2,631.13 | 1,349.77 | 108.23 | 5.25 | 5.28 | 4.68 | 4.34 | 3.06 | 1,559.69 | 37,696 |
| Average - Developing | 624.94 | 540.32 | 56.97 | 3.75 | 3.97 | 4.35 | 3.14 | 2.48 | 674.21 | 5,299 |
| Average - Total | 1,739.49 | 990.01 | 85.45 | 4.58 | 4.70 | 4.54 | 3.81 | 2.80 | 1,166.14 | 23,298 |
| Standard Deviation - Developed | 9,248.14 | 2,996.50 | 66.50 | 0.71 | 0.48 | 0.69 | 0.74 | 1.23 | 2,880.27 | 15,562 |
| Standard Deviation - Developing | 1,982.81 | 1,114.53 | 60.32 | 0.54 | 0.48 | 0.72 | 0.73 | 0.89 | 1,109.95 | 2,803 |
| Standard Deviation - Total | 7,026.08 | 2,366.32 | 68.17 | 0.98 | 0.82 | 0.72 | 0.95 | 1.12 | 2,292.39 | 20,013 |
| Minimum - Developed | 18.47 | 28.29 | 40.57 | 3.87 | 4.42 | 2.89 | 2.21 | 1.40 | 98.42 | 11,273 |
| Minimum - Developing | 0.05 | 8.05 | 0.74 | 2.83 | 2.83 | 3.07 | 2.05 | 1.25 | 24.71 | 1,118 |
| Maximum - Developed | 46,735.90 | 15,077.30 | 348.58 | 6.08 | 5.99 | 6.11 | 5.36 | 6.07 | 14,119.00 | 79,089 |
| Maximum- Developing | 8,956.19 | 5,007.65 | 229.61 | 5.05 | 4.62 | 5.68 | 4.91 | 4.45 | 4,985.46 | 9,644 |

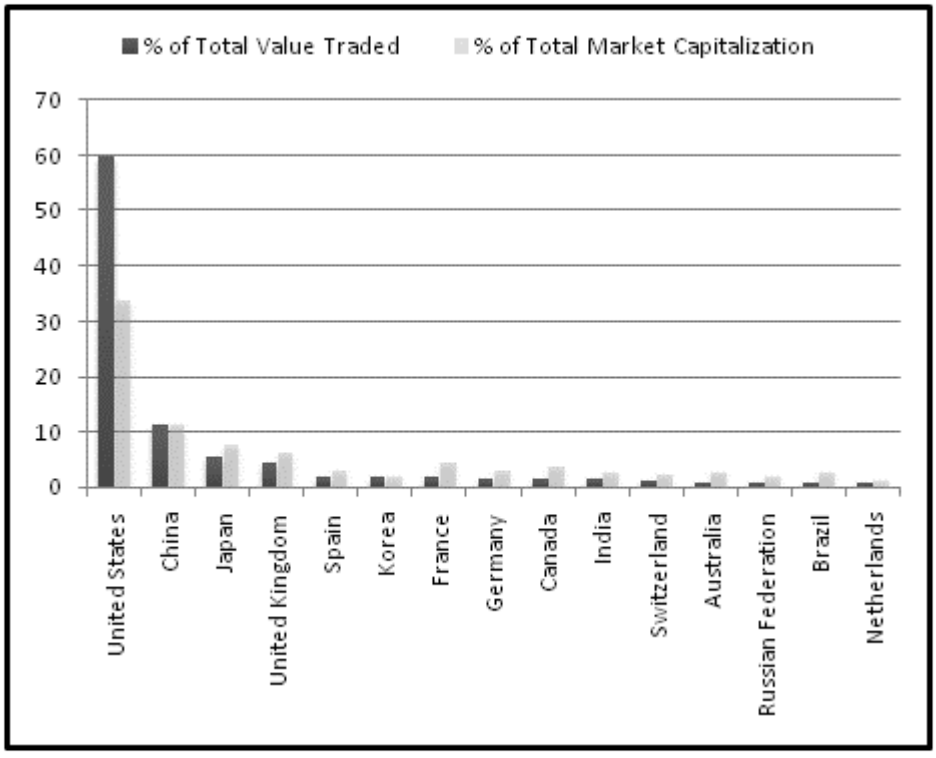


**Figure 3.3: The biggest 15 markets in 2009**

**Table 3.18: Input and output values for 2009**

| Country | Value Traded (Billion USD) | Market Capitalization (Billion USD) | Turnover Ratio (%) | Institutional Environment | Business Environment | Financial Stability | Banking Financial Services | Non-Banking Financial Services | GDP (Billion USD) | GDP per Capita (USD) |
|---|---|---|---|---|---|---|---|---|---|---|
| Argentina | 2.73 | 48.93 | 5.39 | 3.21 | 4.02 | 3.24 | 2.93 | 2.48 | 307.16 | 7,626 |
| Australia | 761.82 | 1,258.46 | 78.78 | 5.47 | 5.48 | 5.21 | 5.06 | 3.96 | 924.84 | 42,279 |
| Austria | 25.53 | 53.58 | 40.57 | 5.66 | 5.37 | 4.80 | 4.21 | 1.96 | 381.08 | 45,562 |
| Belgium | 127.80 | 261.43 | 59.60 | 5.59 | 5.54 | 4.83 | 4.88 | 2.55 | 471.16 | 43,671 |
| Brazil | 649.19 | 1,167.33 | 73.91 | 3.61 | 3.80 | 5.15 | 3.22 | 3.56 | 1,573.41 | 8,121 |
| Canada | 1,239.63 | 1,680.96 | 92.40 | 5.87 | 5.72 | 5.03 | 4.76 | 4.49 | 1,336.07 | 39,599 |
| Chile | 37.57 | 209.48 | 21.97 | 4.46 | 4.53 | 5.38 | 3.24 | 1.86 | 163.67 | 9,644 |
| China | 8,956.19 | 5,007.65 | 229.61 | 4.08 | 4.26 | 4.93 | 4.91 | 4.45 | 4,985.46 | 3,744 |
| Colombia | 12.95 | 133.30 | 11.75 | 3.52 | 4.33 | 4.44 | 2.65 | 2.06 | 234.05 | 5,126 |
| Czech Republic | 20.61 | 52.69 | 40.59 | 4.20 | 4.67 | 4.79 | 3.88 | 1.73 | 190.27 | 18,139 |
| Egypt | 52.81 | 89.95 | 60.07 | 3.85 | 3.81 | 4.39 | 3.03 | 2.14 | 188.41 | 2,270 |
| Finland | 91.17 | 91.02 | 74.30 | 5.78 | 5.87 | 5.09 | 4.08 | 2.12 | 237.99 | 44,581 |
| France | 1,365.81 | 1,972.04 | 78.85 | 5.51 | 5.56 | 5.13 | 4.09 | 3.39 | 2,649.39 | 41,051 |
| Germany | 1,288.87 | 1,297.57 | 107.16 | 5.78 | 5.51 | 4.72 | 4.33 | 3.43 | 3,330.03 | 40,670 |
| Hungary | 25.94 | 28.29 | 110.69 | 4.59 | 4.75 | 2.89 | 2.21 | 1.52 | 128.96 | 12,868 |
| India | 1,088.89 | 1,179.24 | 119.35 | 3.21 | 3.35 | 4.03 | 3.06 | 3.53 | 1,310.17 | 1,134 |
| Indonesia | 115.31 | 178.19 | 83.27 | 3.54 | 3.22 | 4.39 | 2.61 | 2.07 | 540.27 | 2,349 |
| Ireland | 18.47 | 29.88 | 46.60 | 5.55 | 5.36 | 3.60 | 5.07 | 3.18 | 227.19 | 51,049 |
| Israel | 88.29 | 182.10 | 55.78 | 5.13 | 4.45 | 4.47 | 4.15 | 2.21 | 195.39 | 26,256 |
| Italy | 459.73 | 317.32 | 109.70 | 4.32 | 4.76 | 4.29 | 4.13 | 2.70 | 2,112.78 | 35,084 |
| Japan | 4,192.62 | 3,377.89 | 128.80 | 5.54 | 5.13 | 4.46 | 5.17 | 4.14 | 5,069.00 | 39,738 |
| Kazakhstan | 4.04 | 57.66 | 9.10 | 3.23 | 4.16 | 3.82 | 2.86 | 2.55 | 115.31 | 7,257 |
| Korea | 1,581.49 | 836.46 | 237.62 | 4.11 | 5.33 | 4.15 | 3.96 | 4.15 | 832.51 | 17,078 |
| Kuwait | 69.93 | 95.94 | 68.86 | 3.87 | 4.51 | 4.91 | 3.73 | 1.44 | 98.42 | 35,215 |
| Malaysia | 72.97 | 255.95 | 32.94 | 5.05 | 4.59 | 5.68 | 4.70 | 3.17 | 193.09 | 7,030 |
| Mexico | 77.06 | 340.57 | 26.89 | 3.51 | 3.90 | 4.98 | 2.59 | 1.98 | 874.81 | 8,143 |
| Netherlands | 604.16 | 542.53 | 129.87 | 5.76 | 5.66 | 4.51 | 5.34 | 3.65 | 792.13 | 47,917 |
| Nigeria | 4.57 | 33.32 | 11.01 | 3.63 | 2.83 | 3.07 | 2.43 | 1.25 | 173.00 | 1,118 |
| Norway | 247.76 | 227.23 | 140.31 | 5.88 | 5.62 | 5.37 | 4.33 | 2.13 | 381.77 | 79,089 |
| Panama | 0.05 | 8.05 | 0.74 | 4.28 | 4.14 | 4.09 | 4.03 | 1.65 | 24.71 | 7,155 |
| Peru | 3.14 | 69.75 | 5.00 | 3.67 | 3.83 | 4.82 | 2.73 | 1.63 | 130.33 | 4,469 |
| Philippines | 17.20 | 80.13 | 26.01 | 3.64 | 3.34 | 4.38 | 2.75 | 2.17 | 161.20 | 1,752 |
| Poland | 55.78 | 135.28 | 49.47 | 4.04 | 4.42 | 4.55 | 3.13 | 2.37 | 430.08 | 11,273 |
| Russian Federation | 682.54 | 861.42 | 108.50 | 3.15 | 4.43 | 4.17 | 2.05 | 4.28 | 1,231.89 | 8,684 |
| Saudi Arabia | 336.98 | 318.77 | 119.26 | 4.36 | 5.02 | 6.11 | 3.53 | 1.40 | 369.18 | 14,540 |
| Singapore | 252.27 | 310.77 | 102.80 | 6.08 | 5.91 | 5.66 | 4.64 | 3.61 | 182.23 | 36,537 |
| South Africa | 342.50 | 704.82 | 57.27 | 4.42 | 3.92 | 4.56 | 3.68 | 2.76 | 285.37 | 5,786 |
| Spain | 1,599.26 | 1,297.23 | 142.58 | 4.96 | 4.87 | 3.94 | 5.24 | 3.64 | 1,460.25 | 31,774 |
| Sweden | 390.32 | 432.30 | 113.99 | 6.05 | 5.99 | 4.62 | 4.81 | 2.40 | 406.07 | 43,654 |
| Switzerland | 795.56 | 1,070.69 | 82.30 | 5.66 | 5.80 | 5.64 | 4.52 | 2.75 | 491.92 | 63,629 |
| Thailand | 134.94 | 138.19 | 112.08 | 4.32 | 4.29 | 4.71 | 3.55 | 1.60 | 263.77 | 3,893 |
| Turkey | 243.53 | 225.74 | 141.72 | 3.82 | 4.62 | 3.70 | 3.07 | 1.90 | 614.60 | 8,215 |
| Ukraine | 0.59 | 16.79 | 2.87 | 2.83 | 3.94 | 3.13 | 2.62 | 2.48 | 113.55 | 2,468 |
| United Kingdom | 3,402.50 | 2,796.44 | 146.40 | 5.79 | 5.45 | 3.99 | 5.36 | 5.51 | 2,174.53 | 35,165 |
| United States | 46,735.90 | 15,077.30 | 348.58 | 5.58 | 5.37 | 4.26 | 4.01 | 6.07 | 14,119.00 | 45,989 |

**Source: Worldbank World Development Indicators and WEF Financial Development Report 2010**

When the correlations shown in Table 3.19 between variables for year 2009 are inspected some implications as follows:

- Value traded and market capitalization is highly correlated whereas turnover ratio has a medium correlation with the other two output variables but the degree of correlation is increased compared to the other years.
- Value traded and market capitalization is highly correlated with GDP but not with GDP per capita. However the correlation coefficient between value traded and GDP is less than the past two years.
- GDP per capita is highly correlated with institutional environment, business environment and banking financial services.
- Value traded and market capitalization has low correlation with institutional environment, business environment, financial stability and banking financial services.
- Financial stability has very low correlation with other variables.

**Table 3.19: Correlations of variables for 2009**

| | Value Traded (Billion USD) | Market Capitalization (Billion USD) | Turnover Ratio (%) | Institutional Environment | Business Environment | Financial Stability | Banking Financial Services | Non-Banking Financial Services | GDP (Billion USD) | GDP per Capita (USD) |
|---|---|---|---|---|---|---|---|---|---|---|
| Value Traded (Billion USD) | 1.00 | | | | | | | | | |
| Market Capitalization (Billion USD) | 0.97 | 1.00 | | | | | | | | |
| Turnover Ratio (%) | 0.68 | 0.74 | 1.00 | | | | | | | |
| Institutional Environment | 0.18 | 0.24 | 0.33 | 1.00 | | | | | | |
| Business Environment | 0.15 | 0.19 | 0.40 | 0.87 | 1.00 | | | | | |
| Financial Stability | -0.04 | 0.01 | 0.06 | 0.41 | 0.39 | 1.00 | | | | |
| Banking Financial Services | 0.12 | 0.23 | 0.36 | 0.82 | 0.73 | 0.36 | 1.00 | | | |
| Non-Banking Financial Services | 0.55 | 0.68 | 0.65 | 0.35 | 0.38 | 0.02 | 0.50 | 1.00 | | |
| GDP (Billion USD) | 0.93 | 0.97 | 0.73 | 0.23 | 0.19 | -0.01 | 0.23 | 0.67 | 1.00 | |
| GDP per Capita (USD) | 0.18 | 0.21 | 0.32 | 0.85 | 0.85 | 0.32 | 0.70 | 0.30 | 0.22 | 1.00 |

After classical DEA model is solved by applying CCR and BCC formulation using the input and output data in Table 3.18 the efficiency scores of overall efficiency, pure technical efficiency and scale efficiency is obtained as shown in Table 3.20.

**Table 3.20: Efficiency scores in 2009**

| Country | Stage of Development | Overall Efficiency | Pure Technical Efficiency | Scale Efficiency | Market Capitalization (% of GDP) | Value Traded (% of GDP) | Turnover Ratio (%) |
|---|---|---|---|---|---|---|---|
| China | Developing | 1.000 | 1.000 | 1.000 | 100.46 | 179.67 | 229.61 |
| Hungary | Developed | 1.000 | 1.000 | 1.000 | 21.93 | 20.11 | 110.69 |
| India | Developing | 1.000 | 1.000 | 1.000 | 90.01 | 83.11 | 119.35 |
| Korea | Developed | 1.000 | 1.000 | 1.000 | 100.47 | 189.97 | 237.62 |
| Kuwait | Developed | 1.000 | 1.000 | 1.000 | 97.48 | 71.06 | 68.86 |
| Saudi Arabia | Developed | 1.000 | 1.000 | 1.000 | 86.34 | 91.28 | 119.26 |
| Singapore | Developed | 1.000 | 1.000 | 1.000 | 170.53 | 138.43 | 102.80 |
| South Africa | Developing | 1.000 | 1.000 | 1.000 | 246.46 | 119.76 | 57.27 |
| Switzerland | Developed | 1.000 | 1.000 | 1.000 | 217.65 | 161.72 | 82.30 |
| Thailand | Developing | 1.000 | 1.000 | 1.000 | 52.37 | 51.14 | 112.08 |
| Turkey | Developing | 1.000 | 1.000 | 1.000 | 36.58 | 39.46 | 141.72 |
| United Kingdom | Developed | 1.000 | 1.000 | 1.000 | 128.60 | 156.47 | 146.40 |
| United States | Developed | 1.000 | 1.000 | 1.000 | 105.76 | 327.83 | 348.58 |
| Norway | Developed | 0.924 | 0.969 | 0.954 | 59.52 | 64.90 | 140.31 |
| Indonesia | Developing | 0.914 | 1.000 | 0.914 | 32.98 | 21.34 | 83.27 |
| Egypt | Developing | 0.886 | 1.000 | 0.886 | 47.76 | 28.04 | 60.07 |
| Russian Federation | Developing | 0.886 | 1.000 | 0.886 | 69.99 | 55.46 | 108.50 |
| Canada | Developed | 0.876 | 0.881 | 0.994 | 125.81 | 92.78 | 92.40 |
| Australia | Developed | 0.848 | 0.851 | 0.996 | 136.07 | 82.37 | 78.78 |
| Sweden | Developed | 0.847 | 0.857 | 0.988 | 106.46 | 96.12 | 113.99 |
| Spain | Developed | 0.781 | 0.810 | 0.965 | 88.84 | 109.52 | 142.58 |
| Brazil | Developing | 0.645 | 0.710 | 0.909 | 74.26 | 41.30 | 73.91 |
| Netherlands | Developed | 0.632 | 0.633 | 1.000 | 68.49 | 76.27 | 129.87 |
| France | Developed | 0.617 | 0.618 | 0.998 | 74.43 | 51.55 | 78.85 |
| Italy | Developed | 0.616 | 0.618 | 0.996 | 15.02 | 21.76 | 109.70 |
| Israel | Developed | 0.612 | 0.612 | 1.000 | 93.48 | 45.33 | 55.78 |
| Japan | Developed | 0.607 | 0.610 | 0.996 | 66.66 | 82.74 | 128.80 |
| Malaysia | Developing | 0.601 | 0.637 | 0.943 | 133.59 | 38.08 | 32.94 |
| Philippines | Developing | 0.561 | 1.000 | 0.561 | 49.93 | 10.72 | 26.01 |
| Chile | Developing | 0.540 | 0.861 | 0.627 | 127.99 | 22.95 | 21.97 |
| Finland | Developed | 0.525 | 0.572 | 0.918 | 38.32 | 38.38 | 74.30 |
| Germany | Developed | 0.486 | 0.504 | 0.965 | 38.77 | 38.51 | 107.16 |
| Belgium | Developed | 0.430 | 0.432 | 0.996 | 55.80 | 27.27 | 59.60 |
| Czech Republic | Developed | 0.370 | 0.405 | 0.914 | 27.69 | 10.83 | 40.59 |
| Poland | Developed | 0.341 | 0.392 | 0.870 | 31.45 | 12.97 | 49.47 |
| Ireland | Developed | 0.337 | 0.363 | 0.928 | 13.15 | 8.13 | 46.60 |
| Mexico | Developing | 0.323 | 0.546 | 0.591 | 38.93 | 8.81 | 26.89 |
| Austria | Developed | 0.284 | 0.292 | 0.971 | 13.92 | 6.63 | 40.57 |
| Nigeria | Developing | 0.282 | 1.000 | 0.282 | 19.72 | 2.71 | 11.01 |
| Colombia | Developing | 0.254 | 0.680 | 0.373 | 57.75 | 5.61 | 11.75 |
| Kazakhstan | Developing | 0.237 | 0.866 | 0.273 | 52.82 | 3.70 | 9.10 |
| Peru | Developing | 0.217 | 1.000 | 0.217 | 55.04 | 2.47 | 5.00 |
| Panama | Developing | 0.134 | 1.000 | 0.134 | 32.57 | 0.22 | 0.74 |
| Argentina | Developing | 0.086 | 0.190 | 0.450 | 15.85 | 0.88 | 5.39 |
| Ukraine | Developing | 0.084 | 1.000 | 0.084 | 14.79 | 0.52 | 2.87 |

Table 3.21 is derived from Table 3.20 as a descriptive summary and has some of the implications below:

- 13 countries are overall efficient, 21 countries are pure technical efficient and 15 countries are scale efficient.
- Number of pure technical efficient developing countries is higher than overall efficient developing countries as in other years. However number of overall efficient developed countries is equal to number of overall efficient developed countries.
- Average overall efficiency is 0.66, average pure technical efficiency is 0.80 and average scale efficiency is 0.84.
- Average values of the stock market development indicators of overall efficient countries have increased compared to year 2008.

**Table 3.21: Some statistics derived from Table 3.20**

| | Overall Efficiency | | | Pure Technical Efficiency | | | Scale Efficiency | | |
|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | A | B | C | A | B | C |
| Number of Efficient Countries | 8 | 5 | 13 | 8 | 13 | 21 | 10 | 5 | 15 |
| % of Efficient Countries | 32.00 | 25.00 | 28.89 | 32.00 | 65.00 | 46.67 | 40.00 | 25.00 | 33.33 |
| Average Efficiency | 0.73 | 0.58 | 0.66 | 0.74 | 0.87 | 0.80 | 0.98 | 0.66 | 0.84 |
| Standard Deviation of Efficiency | 0.26 | 0.35 | 0.31 | 0.25 | 0.22 | 0.24 | 0.04 | 0.33 | 0.27 |
| Average Market Capitalization (% of GDP) of Efficient Countries | 116.10 | 105.18 | 11.90 | 116.10 | 65.28 | 84.64 | 109.08 | 105.18 | 107.78 |
| Average Market Capitalization (% of GDP) of Inefficient Countries | 61.99 | 54.93 | 58.68 | 61.99 | 71.60 | 64.79 | 59.46 | 54.93 | 57.20 |
| Average Value Traded (% of GDP) of Efficient Countries | 144.61 | 94.63 | 125.39 | 144.61 | 45.74 | 83.40 | 127.85 | 94.63 | 116.77 |
| Average Value Traded (% of GDP) of Inefficient Countries | 50.95 | 16.19 | 34.65 | 50.95 | 17.33 | 41.14 | 49.63 | 16.19 | 32.91 |
| Average Turnover Ratio (%) of Efficient Countries | 152.07 | 132.01 | 144.35 | 152.07 | 73.65 | 103.62 | 140.22 | 132.01 | 137.48 |
| Average Turnover Ratio (%) of Inefficient Countries | 87.61 | 31.96 | 31.52 | 87.61 | 25.99 | 69.64 | 86.91 | 31.96 | 59.44 |

*A: Developed Countries; B: Developing Countries; C: Countries regarding criteria

The target values calculated by CCR model for three output variables for all inefficient DMUs are given in Table 3.22. Target values determine the value of outputs for those DMUs to be efficient in year 2009 by assuming inputs values are constant.

From the reference table for 2008 (Table 3.23) it can be stated that the first four countries which are most referenced by other countries are Korea, South Africa, United States and Hungary.

It is seen from Table 3.23 that the countries which should take Turkey as a reference for year 2009 are Germany (0.720), Italy (0.714) and Austria (0.110).

**Table 3.22: Target values for outputs in 2009**

| | Value Traded (Billion USD) | | Market Capitalization (Billion USD) | | Turnover Ratio (%) | |
|---|---|---|---|---|---|---|
| Country | Original Value | Target Value | Original Value | Target Value | Original Value | Target Value |
| Argentina | 2.73 | 453.25 | 48.93 | 571.36 | 5.39 | 62.94 |
| Australia | 761.82 | 1,434.22 | 1,258.46 | 1,484.69 | 78.78 | 95.45 |
| Austria | 25.53 | 369.01 | 53.58 | 273.27 | 40.57 | 143.10 |
| Belgium | 127.80 | 735.90 | 261.43 | 607.81 | 59.60 | 138.57 |
| Brazil | 649.19 | 3,682.51 | 1,167.33 | 1,808.93 | 73.91 | 114.53 |
| Canada | 1,239.63 | 2,669.08 | 1,680.96 | 1,919.62 | 92.40 | 106.37 |
| Chile | 37.57 | 200.40 | 209.48 | 387.78 | 21.97 | 40.67 |
| Colombia | 12.95 | 326.76 | 133.30 | 525.42 | 11.75 | 46.31 |
| Czech Republic | 20.61 | 178.49 | 52.69 | 142.29 | 40.59 | 109.62 |
| Egypt | 52.81 | 108.13 | 89.95 | 112.53 | 60.07 | 67.79 |
| Finland | 91.17 | 206.65 | 91.02 | 173.28 | 74.30 | 141.45 |
| France | 1,365.81 | 8,124.75 | 1,972.04 | 3,196.34 | 78.85 | 127.80 |
| Germany | 1,288.87 | 9,479.06 | 1,297.57 | 3,234.58 | 107.16 | 220.31 |
| Indonesia | 115.31 | 423.85 | 178.19 | 442.91 | 83.27 | 91.13 |
| Ireland | 18.47 | 213.60 | 29.88 | 127.47 | 46.60 | 138.37 |
| Israel | 88.29 | 160.35 | 182.10 | 297.77 | 55.78 | 91.21 |
| Italy | 459.73 | 5,521.75 | 317.32 | 1,940.10 | 109.70 | 178.22 |
| Japan | 4,192.62 | 16,104.40 | 3,377.89 | 5,563.39 | 128.80 | 212.13 |
| Kazakhstan | 4.04 | 131.81 | 57.66 | 243.36 | 9.10 | 38.41 |
| Malaysia | 72.97 | 213.65 | 255.95 | 426.01 | 32.94 | 54.83 |
| Mexico | 77.06 | 2,394.05 | 340.57 | 1,055.94 | 26.89 | 83.37 |
| Netherlands | 604.16 | 1,576.91 | 542.53 | 857.82 | 129.87 | 205.34 |
| Nigeria | 4.57 | 121.51 | 33.32 | 129.49 | 11.01 | 39.03 |
| Norway | 247.76 | 447.07 | 227.23 | 309.28 | 140.31 | 151.89 |
| Panama | 0.05 | 29.93 | 8.05 | 59.88 | 0.74 | 5.51 |
| Peru | 3.14 | 156.42 | 69.75 | 321.90 | 5.00 | 26.16 |
| Philippines | 17.20 | 113.02 | 80.13 | 142.89 | 26.01 | 46.38 |
| Poland | 55.78 | 651.04 | 135.28 | 396.75 | 49.47 | 145.08 |
| Russian Federation | 682.54 | 3,073.26 | 861.42 | 1,272.11 | 108.50 | 122.46 |
| Spain | 1,599.26 | 3,712.73 | 1,297.23 | 1,660.25 | 142.58 | 182.48 |
| Sweden | 390.32 | 635.97 | 432.30 | 510.55 | 113.99 | 134.62 |
| Ukraine | 0.59 | 106.52 | 16.79 | 198.99 | 2.87 | 34.01 |

## Table 3.23: Reference table for 2009

| No | Country | Countries Taken as References | | | | | No of being Reference |
|---|---|---|---|---|---|---|---|
| 1 | Australia | 23 (0.486) | 24 (0.283) | 42 (0.245) | | | 0 |
| 2 | Austria | 9 (0.433) | 44 (0.110) | 14 (0.117) | 19 (0.435) | | 0 |
| 3 | Belgium | 14 (0.220) | 9 (0.332) | 25 (0.001) | 19 (0.200) | 23 (0.307) | 0 |
| 4 | Canada | 42 (0.304) | 25 (0.024) | 24 (0.327) | 23 (0.397) | | 0 |
| 5 | Czech Republic | 9 (0.771) | 14 (0.085) | 42 (0.070) | | | 0 |
| 6 | Finland | 23 (0.071) | 19 (0.016) | 9 (1.048) | 14 (0.074) | | 0 |
| 7 | France | 42 (0.264) | 25 (0.161) | 14 (0.069) | 23 (0.486) | | 0 |
| 8 | Germany | 14 (0.216) | 44 (0.720) | 25 (0.192) | | | 0 |
| 9 | Hungary | 9 (1) | | | | | 13 |
| 10 | Ireland | 14 (0.119) | 9 (0.995) | | | | 0 |
| 11 | Israel | 9 (0.607) | 14 (0.007) | 42 (0.390) | | | 0 |
| 12 | Italy | 14 (0.164) | 44 (0.714) | 25 (0.109) | | | 0 |
| 13 | Japan | 24 (0.023) | 23 (0.285) | 25 (0.328) | 14 (0.299) | | 0 |
| 14 | Korea | 14 (1) | | | | | 21 |
| 15 | Kuwait | 15 (1) | | | | | 0 |
| 16 | Netherlands | 9 (0.19) | 14 (0.694) | 23 (0.134) | 19 (0.048) | 25 (0.008) | 0 |
| 17 | Norway | 14 (0.175) | 9 (0.493) | 19 (0.467) | | | 0 |
| 18 | Poland | 42 (0.038) | 14 (0.358) | 43 (0.203) | 9 (0.192) | 19 (0.115) | 0 |
| 19 | Saudi Arabia | 19 (1) | | | | | 8 |
| 20 | Singapore | 20 (1) | | | | | 4 |
| 21 | Spain | 24 (0.076) | 23 (0.176) | 25 (0.051) | 14 (0.586) | | 0 |
| 22 | Sweden | 14 (0.086) | 9 (0.702) | 25 (0.005) | 19 (0.084) | 23 (0.302) | 0 |
| 23 | Switzerland | 23 (1) | | | | | 11 |
| 24 | United Kingdom | 24 (1) | | | | | 5 |
| 25 | United States | 25 (1) | | | | | 13 |
| 26 | Argentina | 24 (0.020) | 23 (0.029) | 42 (0.559) | 14 (0.108) | | 0 |
| 27 | Brazil | 14 (0.176) | 25 (0.043) | 42 (0.454) | 29 (0.139) | | 0 |
| 28 | Chile | 42 (0.498) | 20 (0.118) | | | | 0 |
| 29 | China | 29 (1) | | | | | 2 |
| 30 | Colombia | 23 (0.011) | 42 (0.677) | 25 (0.001) | 14 (0.027) | | 0 |
| 31 | Egypt | 32 (0.028) | 43 (0.575) | | | | 0 |
| 32 | India | 32 (1) | | | | | 4 |
| 33 | Indonesia | 32 (0.313) | 43 (0.450) | 14 (0.014) | | | 0 |
| 34 | Kazakhstan | 9 (0.083) | 42 (0.287) | 20 (0.124) | | | 0 |
| 35 | Malaysia | 9 (0.153) | 42 (0.577) | 20 (0.047) | | | 0 |
| 36 | Mexico | 14 (0.107) | 25 (0.044) | 43 (0.047) | 42 (0.362) | 19 (0.139) | 0 |
| 37 | Nigeria | 43 (0.264) | 32 (0.079) | | | | 0 |
| 38 | Panama | 42 (0.081) | 20 (0.008) | | | | 0 |
| 39 | Peru | 42 (0.457) | | | | | 0 |
| 40 | Philippines | 32 (0.040) | 43 (0.335) | 42 (0.069) | | | 0 |
| 41 | Russian Federation | 29 (0.073) | 14 (0.388) | 25 (0.039) | | | 0 |
| 42 | South Africa | 42 (1) | | | | | 17 |
| 43 | Thailand | 43 (1) | | | | | 7 |
| 44 | Turkey | 44 (1) | | | | | 3 |
| 45 | Ukraine | 43 (0.138) | 9 (0.036) | 42 (0.254) | | | 0 |

## 3.6 EVALUATION OF EFFICIENCY IN TIME BY TFP INDEX

By solving classical Data Envelopment Analysis models for 2007, 2008 and 2009, the efficiency scores were found. However these scores are not enough to compare the efficiency in time. In order to compare efficiency change and to understand indeed the reason of the change Malmquist Total Factor Productivity Index can be used.

Malmquist Total Factor Productivity Index measures total factor productivity change over time using distance functions. It does not require behavioral assumptions such as cost minimization, profit maximization or price information which makes it useful compared to other indexes. Malmquist Total Factor Productivity Index is product of change in efficiency (also called "catching up") by change in technical efficiency.

TFP Index = Change in Efficiency (CE) * Change in Technical Efficiency (CTE) **(3.1)**

In Equation 3.1, CE measures the efficiency catching-up of the regarding DMU. If CE = 1, that means the country is still in the same position relative to the efficient boundary. When CE > 1 the country has moved closer to the frontier, whereas if CE < 1 the country has moved away from the frontier between two periods. Also, CTE indicates the change in technology. CTE < 1 implies a negative shift of the frontier, CTE > 1 implies positive shift (progress) and CTE = 1 implies no shift in the technological frontier (Hadad et al. 2011, p.5).

In this section, first DEA efficiency scores and their analysis will be given then in contact with efficiency scores, efficiencies of countries will be analyzed by using Malmquist Total Factor Productivity Index.

The overall efficiency scores of countries for 2007, 2008 and 2009 and also the average of overall efficiency scores of these three years is given in Table 3.24.

**Table 3.24: 2007, 2008 and 2009 overall efficiency scores**

| Country | State of Development | 2007 Overall Efficiency | 2008 Overall Efficiency | 2009 Overall Efficiency | Average of Overall Efficiency |
|---|---|---|---|---|---|
| China | Developing | 1.000 | 1.000 | 1.000 | 1.000 |
| Hungary | Developed | 1.000 | 1.000 | 1.000 | 1.000 |
| India | Developing | 1.000 | 1.000 | 1.000 | 1.000 |
| Korea | Developed | 1.000 | 1.000 | 1.000 | 1.000 |
| Saudi Arabia | Developed | 1.000 | 1.000 | 1.000 | 1.000 |
| Singapore | Developed | 1.000 | 1.000 | 1.000 | 1.000 |
| South Africa | Developing | 1.000 | 1.000 | 1.000 | 1.000 |
| Switzerland | Developed | 1.000 | 1.000 | 1.000 | 1.000 |
| Turkey | Developing | 1.000 | 1.000 | 1.000 | 1.000 |
| United Kingdom | Developed | 1.000 | 1.000 | 1.000 | 1.000 |
| United States | Developed | 1.000 | 1.000 | 1.000 | 1.000 |
| Kuwait | Developed | 0.961 | 1.000 | 1.000 | 0.987 |
| Thailand | Developing | 0.924 | 1.000 | 1.000 | 0.975 |
| Indonesia | Developing | 1.000 | 1.000 | 0.914 | 0.971 |
| Egypt | Developing | 1.000 | 1.000 | 0.886 | 0.962 |
| Spain | Developed | 0.931 | 0.958 | 0.781 | 0.890 |
| Norway | Developed | 0.778 | 0.926 | 0.924 | 0.876 |
| Sweden | Developed | 0.812 | 0.962 | 0.847 | 0.874 |
| Italy | Developed | 1.000 | 1.000 | 0.616 | 0.872 |
| Netherlands | Developed | 1.000 | 0.922 | 0.632 | 0.851 |
| Finland | Developed | 1.000 | 1.000 | 0.525 | 0.842 |
| Canada | Developed | 0.775 | 0.731 | 0.876 | 0.794 |
| Russian Federation | Developing | 0.626 | 0.754 | 0.886 | 0.755 |
| Australia | Developed | 0.752 | 0.647 | 0.848 | 0.749 |
| Japan | Developed | 0.665 | 0.822 | 0.607 | 0.698 |
| France | Developed | 0.652 | 0.756 | 0.617 | 0.675 |
| Malaysia | Developing | 0.836 | 0.544 | 0.601 | 0.660 |
| Germany | Developed | 0.755 | 0.669 | 0.486 | 0.637 |
| Israel | Developed | 0.638 | 0.649 | 0.612 | 0.633 |
| Brazil | Developing | 0.571 | 0.642 | 0.645 | 0.619 |
| Philippines | Developing | 0.794 | 0.450 | 0.561 | 0.602 |
| Nigeria | Developing | 0.806 | 0.710 | 0.282 | 0.599 |
| Czech Republic | Developed | 0.645 | 0.744 | 0.370 | 0.586 |
| Ireland | Developed | 0.534 | 0.632 | 0.337 | 0.501 |
| Chile | Developing | 0.477 | 0.465 | 0.540 | 0.494 |
| Belgium | Developed | 0.426 | 0.512 | 0.430 | 0.456 |
| Poland | Developed | 0.390 | 0.397 | 0.341 | 0.376 |
| Austria | Developed | 0.344 | 0.499 | 0.284 | 0.376 |
| Mexico | Developing | 0.280 | 0.343 | 0.323 | 0.315 |
| Kazakhstan | Developing | 0.362 | 0.223 | 0.237 | 0.274 |
| Peru | Developing | 0.350 | 0.242 | 0.217 | 0.270 |
| Colombia | Developing | 0.231 | 0.258 | 0.254 | 0.248 |
| Panama | Developing | 0.152 | 0.324 | 0.134 | 0.203 |
| Argentina | Developing | 0.165 | 0.238 | 0.086 | 0.163 |
| Ukraine | Developing | 0.269 | 0.087 | 0.084 | 0.147 |

When the data given in Table 3.24 analyzed, some of implications can be as follows:

- **Countries found efficient in all three years:**

i) Developed Countries: Hungary, Korea, Saudi Arabia, Singapore, Switzerland, United Kingdom, United States (7 countries in total),

ii) Developing Countries: China, India, South Africa, Turkey (4 countries in total),

- **Countries found efficient in any two years:**

i) Developed Countries: Italy, Finland, Kuwait (3 countries in total),

ii) Developing Countries: Indonesia, Egypt, Thailand (3 countries in total),

- **Countries found efficient in only one year:**

i) Developed Countries: Netherlands,

ii) Developing Countries: None

- **Countries found inefficient in all three years**:

i) Developed Countries: Norway, Canada, Australia, Sweden, Spain, France, Israel, Japan, Germany, Belgium, Czech Republic, Poland, Ireland, Austria (14 countries in total),

ii) Developing Countries: Russian Federation, Brazil, Malaysia, Philippines, Chile, Mexico, Nigeria, Colombia, Kazakhstan, Peru, Panama, Argentina, Ukraine (13 countries in total).

As seen, except countries found efficient in all three years, according to the stage of development, the number of countries in the categories are very close.

From the Table 3.25 it can be stated that, number of countries found efficient in each type of efficiency is minimum in 2009. Number of pure technical efficient developing countries is more than twice of overall efficient countries whereas it is not valid for developed countries.

**Table 3.25: Number of efficient and inefficient countries for three years**

| | Overall Efficiency | | | Pure Technical Efficiency | | | Scale Efficiency | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | A | B | C | A | B | C | A | B | C |
| 2007 | 10 | 6 | 16 | 12 | 16 | 28 | 11 | 6 | 17 |
| 2008 | 10 | 7 | 17 | 11 | 15 | 26 | 10 | 7 | 17 |
| 2009 | 8 | 5 | 13 | 8 | 13 | 21 | 10 | 5 | 15 |

*A: Developed Countries; B: Developing Countries; C: All Countries

In Figure 3.4, the overall efficiency scores of three years given as three categories; developed, developing and all countries. As seen the average of the overall efficiency scores of the developed countries is higher in each three years and it first slightly increases then decreases. However the average of the overall efficiency scores of the developing countries decreases with a linear trend.

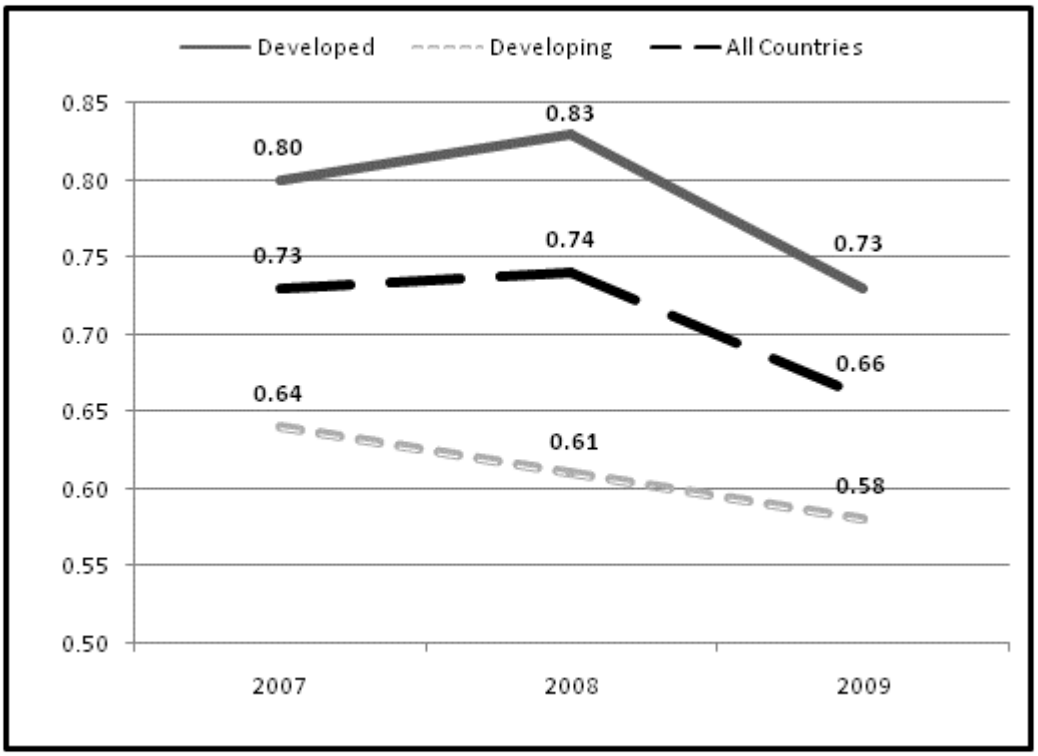


**Figure 3.4: Overall efficiency scores of three years according to stage of development**

As explained in the beginning of this section to take only the efficiency scores in consideration may be captious to evaluate change in efficiency. In order to evaluate change in efficiency in time, Malmquist Total Factor Productivity Index can be employed.

In Table 3.26, Malmquist Total Factor Productivity Index calculated by Deap 2.1 is given. As seen, average change in efficiency (CE) is greater than 1 from 2007 to 2008 and less than 1 from 2008 to 2009. Also, average change in Technical efficiency (CTE) is less than 1 from 2007 to 2008 and greater than 1 from 2008 to 2009. Similarly, Total

Factor Productivity Index (TFP Index) is less than 1 from 2007 to 2008 and greater than 1 from 2008 to 2009.

The average of Total Factor Productivity Index is 0.953 which indicates a decrease in 2008 and 2009 in the average with respect to 2007. According to the average of Total Factor Productivity Index 16 countries has an index value which is greater than 1, these countries are Thailand, Russian Federation, Australia, United States, Mexico, Hungary, Brazil, Korea, Chile, Indonesia, Colombia, Canada, Turkey, China, India and United Kingdom. 10 of these 16 countries are developing countries which implies that developing countries have gained more importance in the period 2007-2009. When the global financial crisis which reached to peak in 2008 is thought, this result is meaningful.

Additional comments can be made by the help of Figure 3.5. As seen in Figure 3.5 Total Factor Productivity Index for developed countries is decreasing in 2008 less than those of developing countries but increasing in 2009 less than developing countries. This is another meaningful result to evaluate the direction of stock markets in the financial crisis.

The first 5 countries according to the average of the value traded in billion USD in the period 2007-2009 were United States, China, United Kingdom, Japan and France. When these countries evaluated in terms of TFP Index, it is seen that in this period United States, China and United Kingdom have an average TFP Index greater than 1. In the same period Japan and France have an average TFP Index less than 1.

**Table 3.26: Change in Efficiency (CE), change in technical efficiency (CTE) and TFP Index**

| | | 2007-2008 | | | 2008-2009 | | | |
|---|---|---|---|---|---|---|---|---|
| Country | Stage of Development | CE | CTE | TFP Index | CE | CTE | TFP Index | Average of TFP Index |
| Thailand | Developing | 1.082 | 1.040 | 1.125 | 1.000 | 1.437 | 1.437 | 1.281 |
| Russian Fed. | Developing | 1.205 | 0.773 | 0.931 | 1.175 | 1.282 | 1.507 | 1.219 |
| Australia | Developed | 0.860 | 0.684 | 0.588 | 1.310 | 1.279 | 1.676 | 1.132 |
| United States | Developed | 1.000 | 0.866 | 0.866 | 1.000 | 1.397 | 1.397 | 1.132 |
| Mexico | Developing | 1.222 | 0.796 | 0.972 | 0.942 | 1.294 | 1.219 | 1.096 |
| Hungary | Developed | 1.000 | 0.861 | 0.861 | 1.000 | 1.325 | 1.325 | 1.093 |
| Brazil | Developing | 1.125 | 0.664 | 0.747 | 1.005 | 1.427 | 1.433 | 1.090 |
| Korea | Developed | 1.000 | 0.856 | 0.856 | 1.000 | 1.315 | 1.315 | 1.086 |
| Chile | Developing | 0.976 | 0.689 | 0.672 | 1.162 | 1.287 | 1.495 | 1.084 |
| Indonesia | Developing | 1.000 | 1.003 | 1.003 | 0.914 | 1.272 | 1.162 | 1.083 |
| Colombia | Developing | 1.118 | 0.813 | 0.909 | 0.982 | 1.276 | 1.254 | 1.082 |
| Canada | Developed | 0.944 | 0.636 | 0.600 | 1.198 | 1.296 | 1.552 | 1.076 |
| Turkey | Developing | 1.000 | 0.829 | 0.829 | 1.000 | 1.240 | 1.240 | 1.035 |
| China | Developing | 1.000 | 0.497 | 0.497 | 1.000 | 1.566 | 1.566 | 1.032 |
| India | Developing | 1.000 | 0.670 | 0.670 | 1.000 | 1.378 | 1.378 | 1.024 |
| United Kingdom | Developed | 1.000 | 0.755 | 0.755 | 1.000 | 1.273 | 1.273 | 1.014 |
| Norway | Developed | 1.190 | 0.813 | 0.967 | 0.998 | 1.014 | 1.012 | 0.990 |
| Panama | Developing | 2.129 | 0.670 | 1.426 | 0.415 | 1.318 | 0.547 | 0.987 |
| South Africa | Developing | 1.000 | 0.728 | 0.728 | 1.000 | 1.237 | 1.237 | 0.983 |
| Philippines | Developing | 0.566 | 1.006 | 0.570 | 1.247 | 1.089 | 1.359 | 0.965 |
| Egypt | Developing | 1.000 | 1.019 | 1.019 | 0.886 | 1.016 | 0.900 | 0.960 |
| Malaysia | Developing | 0.650 | 0.779 | 0.506 | 1.105 | 1.250 | 1.382 | 0.944 |
| Kuwait | Developed | 1.040 | 0.744 | 0.774 | 1.000 | 1.109 | 1.109 | 0.942 |
| Sweden | Developed | 1.184 | 0.794 | 0.940 | 0.880 | 1.071 | 0.943 | 0.942 |
| Poland | Developed | 1.019 | 0.777 | 0.791 | 0.858 | 1.258 | 1.079 | 0.935 |
| Saudi Arabia | Developed | 1.000 | 0.693 | 0.693 | 1.000 | 1.176 | 1.176 | 0.935 |
| France | Developed | 1.159 | 0.744 | 0.862 | 0.816 | 1.224 | 0.999 | 0.931 |
| Kazakhstan | Developing | 0.616 | 0.774 | 0.477 | 1.063 | 1.289 | 1.370 | 0.924 |
| Japan | Developed | 1.236 | 0.709 | 0.877 | 0.739 | 1.310 | 0.968 | 0.923 |
| Singapore | Developed | 1.000 | 0.663 | 0.663 | 1.000 | 1.177 | 1.177 | 0.920 |
| Belgium | Developed | 1.201 | 0.777 | 0.933 | 0.840 | 1.077 | 0.906 | 0.920 |
| Israel | Developed | 1.017 | 0.688 | 0.699 | 0.943 | 1.157 | 1.091 | 0.895 |
| Spain | Developed | 1.029 | 0.776 | 0.799 | 0.816 | 1.210 | 0.987 | 0.893 |
| Switzerland | Developed | 1.000 | 0.710 | 0.710 | 1.000 | 1.030 | 1.030 | 0.870 |
| Austria | Developed | 1.451 | 0.765 | 1.110 | 0.569 | 1.019 | 0.579 | 0.845 |
| Netherlands | Developed | 0.922 | 0.827 | 0.762 | 0.686 | 1.331 | 0.913 | 0.838 |
| Peru | Developing | 0.693 | 0.669 | 0.463 | 0.894 | 1.338 | 1.196 | 0.830 |
| Italy | Developed | 1.000 | 1.201 | 1.201 | 0.616 | 0.691 | 0.425 | 0.813 |
| Germany | Developed | 0.887 | 1.063 | 0.943 | 0.727 | 0.932 | 0.677 | 0.810 |
| Ireland | Developed | 1.184 | 0.819 | 0.970 | 0.533 | 1.177 | 0.627 | 0.799 |
| Argentina | Developing | 1.436 | 0.770 | 1.105 | 0.361 | 1.352 | 0.487 | 0.796 |
| Czech Republic | Developed | 1.154 | 0.796 | 0.919 | 0.497 | 1.152 | 0.573 | 0.746 |
| Ukraine | Developing | 0.325 | 0.728 | 0.236 | 0.965 | 1.181 | 1.140 | 0.688 |
| Nigeria | Developing | 0.881 | 1.011 | 0.890 | 0.397 | 1.141 | 0.453 | 0.672 |
| Finland | Developed | 1.000 | 0.758 | 0.758 | 0.525 | 1.002 | 0.526 | 0.642 |
| | ***Average*** | 1.033 | 0.793 | 0.815 | 0.890 | 1.215 | 1.091 | 0.953 |

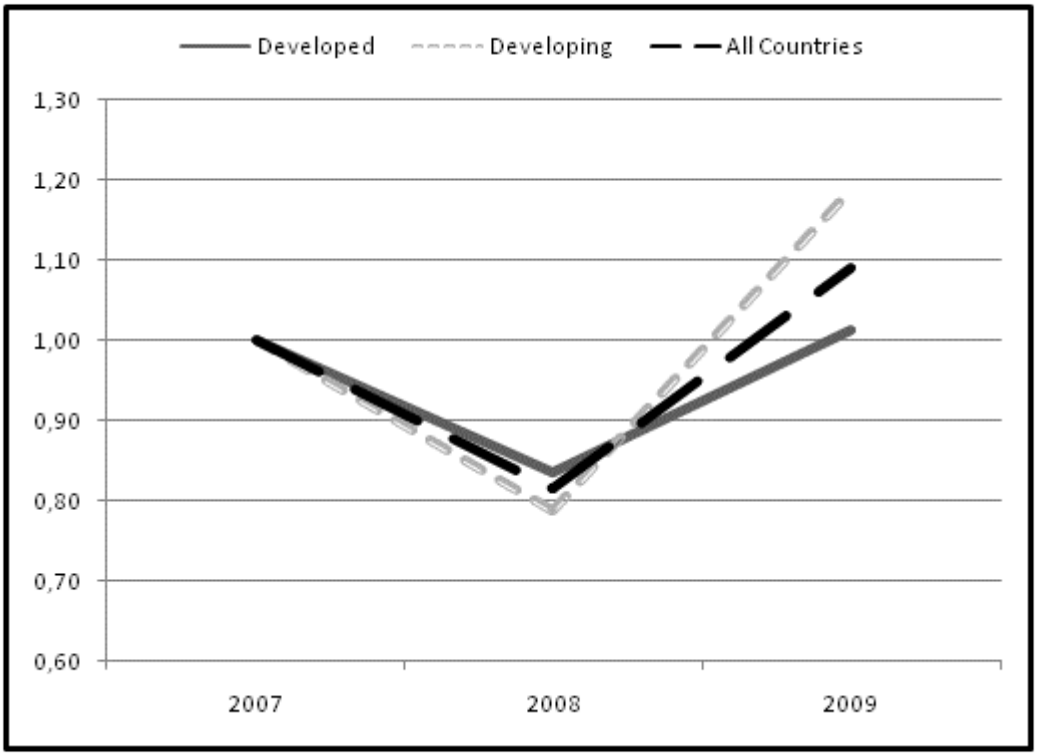


**Figure 3.5: TFP Index for 2007 - 2009**

To gain a deeper understanding about the relation between overall efficiency change and change in total factor productivity, selected two countries will be analyzed.

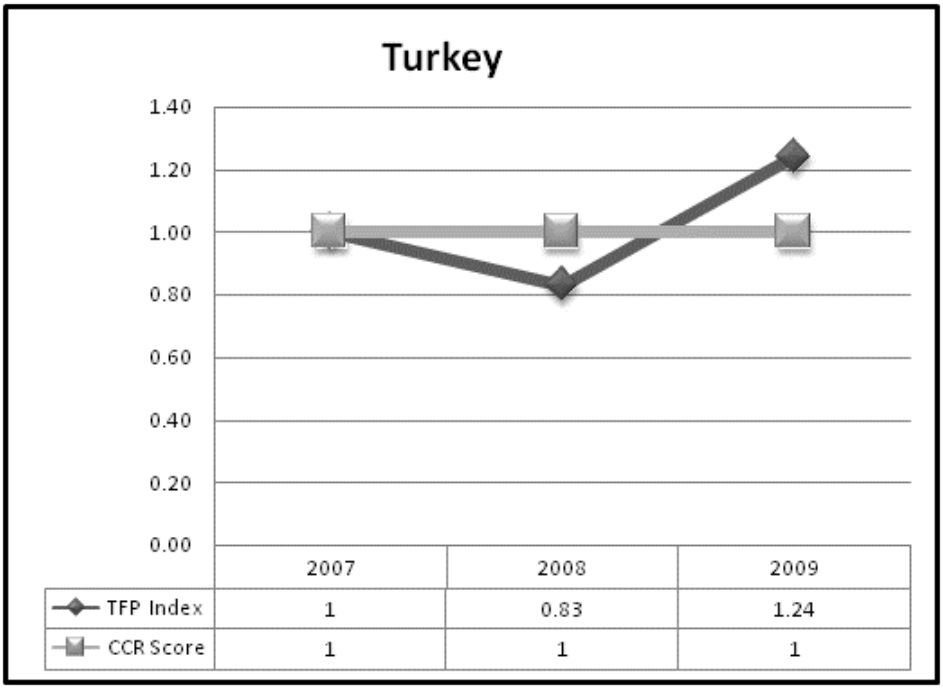


**Figure 3.6: Overall efficiency and TFP Index for Turkey**

The first country to be analyzed is Turkey. As seen in Figure 3.6, CCR score (overall efficiency) of Turkey is 1 in all of the three years whereas TFP Index is decreasing from 2007 to 2008 and then increasing from 2008 to 2009. Although efficiency score did not changed total factor productivity is increased. This implies a success in technical efficiency.

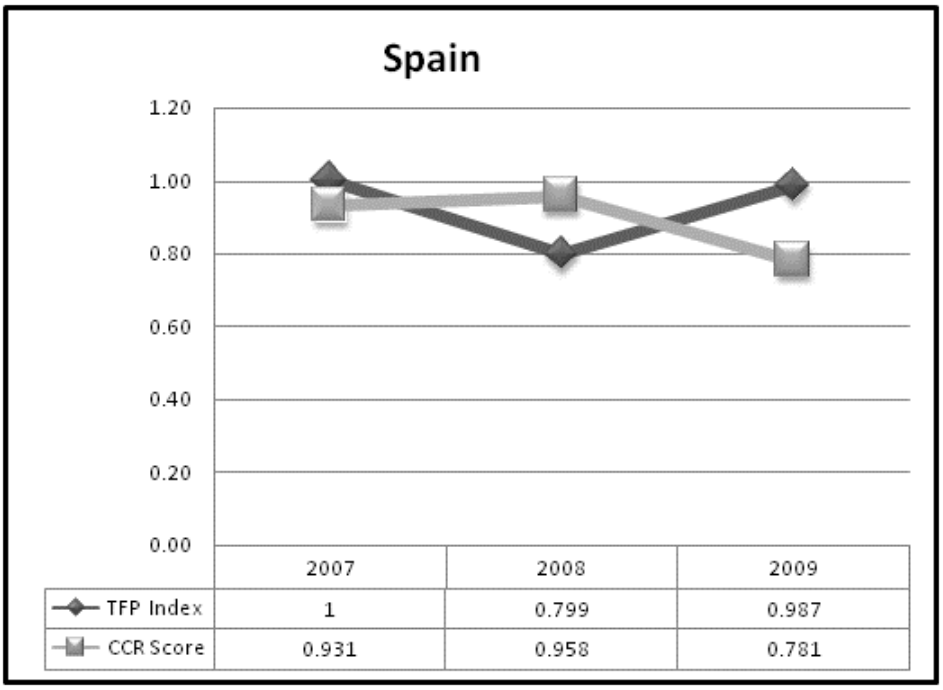


**Figure 3.7: Overall efficiency and TFP Index for Spain**

Another country to be analyzed is Spain. As seen in Figure 3.7 CCR score (overall efficiency) of Spain is increasing slightly from 2007 to 2008 but TFP Index is decreasing. This implies a failure in technical efficiency. Additionally CCR score (overall efficiency) of Spain is decreasing from 2008 to 2009 but TFP Index is increasing. This implies a success in technical efficiency.

There are many alternative trends changing from country to country. All the figures belonging 45 countries in the study are given in Appendix 1 to make evaluations about the efficiency change and total factor productivity change.

## 3.7 APPLICATION AND RESULTS OF FUZZY DEA

In this section Wang, Greatbanks and Yang (2005) approach is used to solve Fuzzy Data Envelopment Analysis (FDEA) model. In this FDEA model the inputs and outputs are same as in classical DEA model. In Wang, Greatbanks and Yang (2005) there are two efficiency scores instead of one score. They are lower bound efficiency and upper bound efficiency. In order to remind LP models for lower and upper bound efficiencies of Wang, Greatbanks and Yang (2005), they are given below

LP Model for Lower Bound Efficiency:

$$\text{Maximize } \theta_{j0}^{L} = \sum_{r=1}^{s} u_r \, y_{rj0}^{L} \qquad \textbf{(3.2)}$$

$$subject\ to \ \ \sum_{i=1}^{m} v_i x_{ij0}^{U} = 1,$$

$$\sum_{r=1}^{s} u_r y_{rj}^{U} - \sum_{i=1}^{m} v_i x_{ij}^{L} \leq 0, \quad j = 1,2,..,n$$

$$u_r, v_i \geq \varepsilon \quad \forall r, i.$$

LP Model for Upper Bound Efficiency:

$$\text{Maximize } \theta_{j0}^{L} = \sum_{r=1}^{s} u_r \, y_{rj0}^{U} \qquad \textbf{(3.3)}$$

$$subject\ to \ \ \sum_{i=1}^{m} v_i x_{ij0}^{L} = 1,$$

$$\sum_{r=1}^{s} u_r y_{rj}^{U} - \sum_{i=1}^{m} v_i x_{ij}^{L} \leq 0, \quad j = 1,2,..,n$$

$$u_r, v_i \geq \varepsilon \quad \forall r, i.$$

In order to solve these LP formulations one needs to know lower and upper boundaries. Lower and upper boundaries will be found applying α-cut sets approach of Zimmermann (1991) on triangular fuzzy numbers. In this study, elements of triangular fuzzy numbers are taken as values of input and output variables in each three year (2007, 2008, and 2009). For a variable, the minimum of the three years' values is the smallest possible value (a), the maximum of the three years' values is the largest possible value (b), and the other is the most promising value (m).

For a variable, the lower bound and upper bound can be found as follows:

$$\text{Lower Bound} = L = a + \alpha\,(m-a) \quad \textbf{(3.4)}$$

$$\text{Upper Bound} = U = b - \alpha\,(b-m) \quad \textbf{(3.5)}$$

An example of calculating lower and upper bounds will be given as using value traded variable of Turkey. The values of the value traded of Turkey in years 2007, 2008 and 2009 are 302.40, 239.71 and 243.53 respectively. When converted triangular fuzzy number;

a = 239.71; m = 243.53 and b = 302.40.

The lower bound for α = 0.25 is
L = 239.71 + 0.25(243.53-239.71) = 240.67
The upper bound for α = 0.25 is
U = 302.40 – 0.25(302.40-243.53) = 287.68.

The lower bound for α = 0.50 is
L = 239.71 + 0.50(243.53-239.71) = 241.62
The upper bound for α = 0.50 is
U = 302.40 – 0.50(302.40-243.53) = 272.96.

The lower bound for α = 0.75 is
L = 239.71 + 0.75(243.53-239.71) = 242.57
The upper bound for α = 0.50 is
U = 302.40 – 0.75(302.40-243.53) = 258.24.

As seen in Figure 3.8, the smallest interval can be obtained when α = 0.75 and the largest interval is obtained when α = 0.25. Furthermore, efficiency scores are generally getting higher as α is getting higher (See Table 3.27).

For all variables of each DMU's lower and upper bounds are calculated and given in Appendix 2. Using the lower and upper bounds given Appendix 2 and solving LP models in Microsoft Excel Solver for α = 0.25, 0.50 and 0.75, the lower bound and upper bound efficiency scores are calculated and given in Table 3.27.

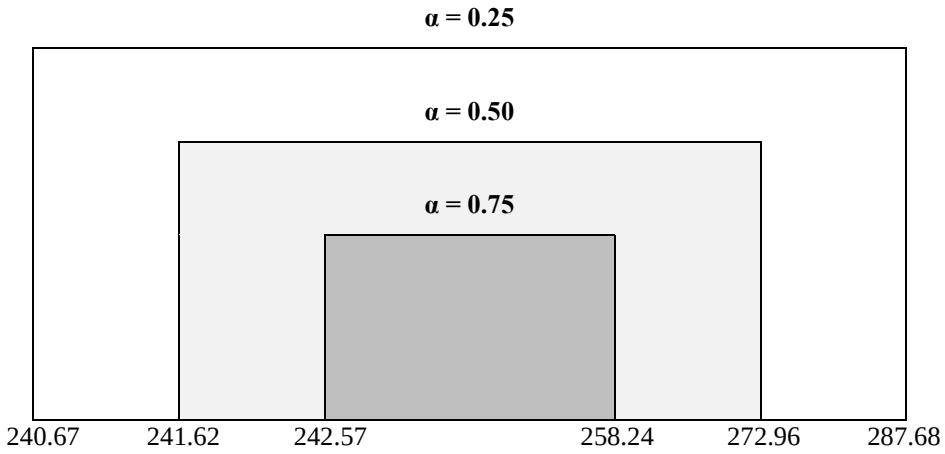


**Figure 3.8: Intervals for three α levels**

In Table 3.27, average of 2007, 2008 and 2009 overall efficiency scores obtained by using classical DEA and minimum absolute distances to these scores are given besides FDEA results. As seen average of lower bound efficiencies of 45 countries for α = 0.25, 0.50 and 0.75 are 0.481, 0.553 and 0.636 respectively. Average of upper bound efficiencies of 45 countries are 0.730 for all α levels. However, minimum of upper bound efficiency scores is decreasing while α is increasing.

Another implication from Table 3.27 is about minimum absolute difference to average of 2007, 2008 and 2009 overall efficiency scores obtained by using classical DEA. 26 countries have the minimum difference to average of 2007, 2008 and 2009 overall efficiency scores for upper bound efficiency of α = 0.75; 9 countries for upper bound efficiency of α = 0.25; 5 countries for lower bound efficiency of α = 0.75 and 5 countries for upper bound efficiency of α = 0.50.

**Table 3.27: Lower and upper bound efficiencies for three α levels**

| | α =0.25 | | α =0.50 | | α =0.75 | | | |
|---|---|---|---|---|---|---|---|---|
| Country | Value of Lower Bound Efficiency (1) | Value of Upper Bound Efficiency (2) | Value of Lower Bound Efficiency (3) | Value of Upper Bound Efficiency (4) | Value of Lower Bound Efficiency (5) | Value of Upper Bound Efficiency (6) | Average of 2007-2009 Overall Efficiency in Classical DEA (7) | Minimum Absolute Difference to (7) |
| Argentina | 0.078 | 0.196 | 0.092 | 0.175 | 0.109 | 0.152 | 0.163 | 6 |
| Australia | 0.446 | 0.736 | 0.560 | 0.778 | 0.701 | 0.820 | 0.749 | 2 |
| Austria | 0.249 | 0.402 | 0.289 | 0.402 | 0.339 | 0.399 | 0.376 | 6 |
| Belgium | 0.316 | 0.454 | 0.355 | 0.452 | 0.399 | 0.448 | 0.456 | 2 |
| Brazil | 0.351 | 0.596 | 0.413 | 0.616 | 0.521 | 0.635 | 0.619 | 4 |
| Canada | 0.443 | 0.830 | 0.554 | 0.844 | 0.695 | 0.855 | 0.794 | 2 |
| Chile | 0.363 | 0.476 | 0.412 | 0.496 | 0.469 | 0.516 | 0.494 | 4 |
| China | 0.633 | 1.000 | 0.741 | 1.000 | 0.862 | 1.000 | 1.000 | 6 |
| Colombia | 0.174 | 0.243 | 0.194 | 0.241 | 0.216 | 0.240 | 0.248 | 2 |
| Czech Republic | 0.373 | 0.603 | 0.452 | 0.608 | 0.538 | 0.619 | 0.586 | 2 |
| Egypt | 0.678 | 1.000 | 0.785 | 1.000 | 0.895 | 1.000 | 0.962 | 6 |
| Finland | 0.525 | 1.000 | 0.668 | 1.000 | 0.826 | 1.000 | 0.842 | 5 |
| France | 0.395 | 0.683 | 0.484 | 0.695 | 0.585 | 0.700 | 0.675 | 2 |
| Germany | 0.398 | 0.666 | 0.498 | 0.694 | 0.624 | 0.730 | 0.637 | 5 |
| Hungary | 0.832 | 1.000 | 0.889 | 1.000 | 0.945 | 1.000 | 1.000 | 6 |
| India | 0.753 | 1.000 | 0.826 | 1.000 | 0.909 | 1.000 | 1.000 | 6 |
| Indonesia | 0.724 | 1.000 | 0.821 | 1.000 | 0.908 | 1.000 | 0.971 | 6 |
| Ireland | 0.332 | 0.617 | 0.409 | 0.614 | 0.498 | 0.611 | 0.501 | 5 |
| Israel | 0.452 | 0.627 | 0.499 | 0.618 | 0.548 | 0.607 | 0.633 | 2 |
| Italy | 0.488 | 1.000 | 0.633 | 1.000 | 0.802 | 1.000 | 0.872 | 5 |
| Japan | 0.470 | 0.635 | 0.525 | 0.649 | 0.595 | 0.659 | 0.698 | 6 |
| Kazakhstan | 0.151 | 0.321 | 0.174 | 0.292 | 0.201 | 0.262 | 0.274 | 6 |
| Korea | 0.779 | 1.000 | 0.847 | 1.000 | 0.921 | 1.000 | 1.000 | 6 |
| Kuwait | 0.660 | 1.000 | 0.751 | 1.000 | 0.862 | 1.000 | 0.987 | 6 |
| Malaysia | 0.428 | 0.724 | 0.478 | 0.685 | 0.540 | 0.649 | 0.660 | 6 |
| Mexico | 0.193 | 0.280 | 0.217 | 0.287 | 0.254 | 0.294 | 0.315 | 6 |
| Netherlands | 0.582 | 0.887 | 0.665 | 0.882 | 0.757 | 0.873 | 0.851 | 6 |
| Nigeria | 0.299 | 0.659 | 0.428 | 0.695 | 0.584 | 0.733 | 0.599 | 5 |
| Norway | 0.719 | 0.815 | 0.779 | 0.847 | 0.844 | 0.880 | 0.876 | 6 |
| Panama | 0.103 | 0.225 | 0.122 | 0.206 | 0.140 | 0.184 | 0.203 | 4 |
| Peru | 0.163 | 0.303 | 0.181 | 0.276 | 0.201 | 0.249 | 0.270 | 4 |
| Philippines | 0.370 | 0.586 | 0.422 | 0.580 | 0.489 | 0.575 | 0.602 | 2 |
| Poland | 0.287 | 0.354 | 0.318 | 0.367 | 0.353 | 0.383 | 0.376 | 6 |
| Russian Federation | 0.419 | 0.926 | 0.511 | 0.879 | 0.627 | 0.829 | 0.755 | 6 |
| Saudi Arabia | 0.712 | 1.000 | 0.796 | 1.000 | 0.892 | 1.000 | 1.000 | 6 |
| Singapore | 0.743 | 1.000 | 0.826 | 1.000 | 0.911 | 1.000 | 1.000 | 6 |
| South Africa | 0.785 | 1.000 | 0.860 | 1.000 | 0.934 | 1.000 | 1.000 | 6 |
| Spain | 0.636 | 0.850 | 0.724 | 0.877 | 0.824 | 0.905 | 0.890 | 4 |
| Sweden | 0.595 | 0.884 | 0.670 | 0.886 | 0.776 | 0.891 | 0.874 | 2 |
| Switzerland | 0.701 | 1.000 | 0.791 | 1.000 | 0.891 | 1.000 | 1.000 | 6 |
| Thailand | 0.628 | 1.000 | 0.729 | 1.000 | 0.850 | 1.000 | 0.975 | 6 |
| Turkey | 0.787 | 1.000 | 0.861 | 1.000 | 0.931 | 1.000 | 1.000 | 6 |
| Ukraine | 0.052 | 0.259 | 0.060 | 0.194 | 0.070 | 0.131 | 0.147 | 6 |
| United Kingdom | 0.582 | 1.000 | 0.705 | 1.000 | 0.844 | 1.000 | 1.000 | 6 |
| United States | 0.818 | 1.000 | 0.876 | 1.000 | 0.936 | 1.000 | 1.000 | 6 |
| Average - All | 0.481 | 0.730 | 0.553 | 0.730 | 0.636 | 0.730 | 0.710 | |
| No of Efficient DMUs | 0 | 17 | 0 | 17 | 0 | 17 | | |
| Average - Inefficient | 0.398 | 0.642 | 0.467 | 0.642 | 0.548 | 0.642 | 0.616 | |
| Minimum | 0.052 | 0.196 | 0.060 | 0.175 | 0.070 | 0.131 | 0.147 | |
| Maximum | 0.832 | 1.000 | 0.889 | 1.000 | 0.945 | 1.000 | 1.000 | |

Other interesting results are that none of the countries is efficient in lower bound and number of efficient countries is equal and 17 in upper bound. When consider the number of efficient countries according to the average of overall efficiency in classical DEA results; 16 countries are efficient in 2007, 17 countries are efficient in 2008 and 13 countries are efficient in 2009, it can be stated that upper bound efficiency in FDEA produces generally better efficiency scores as compared classical DEA.

A graphical presentation of average, minimum and maximum scores of FDEA model is given in Figure3.9.

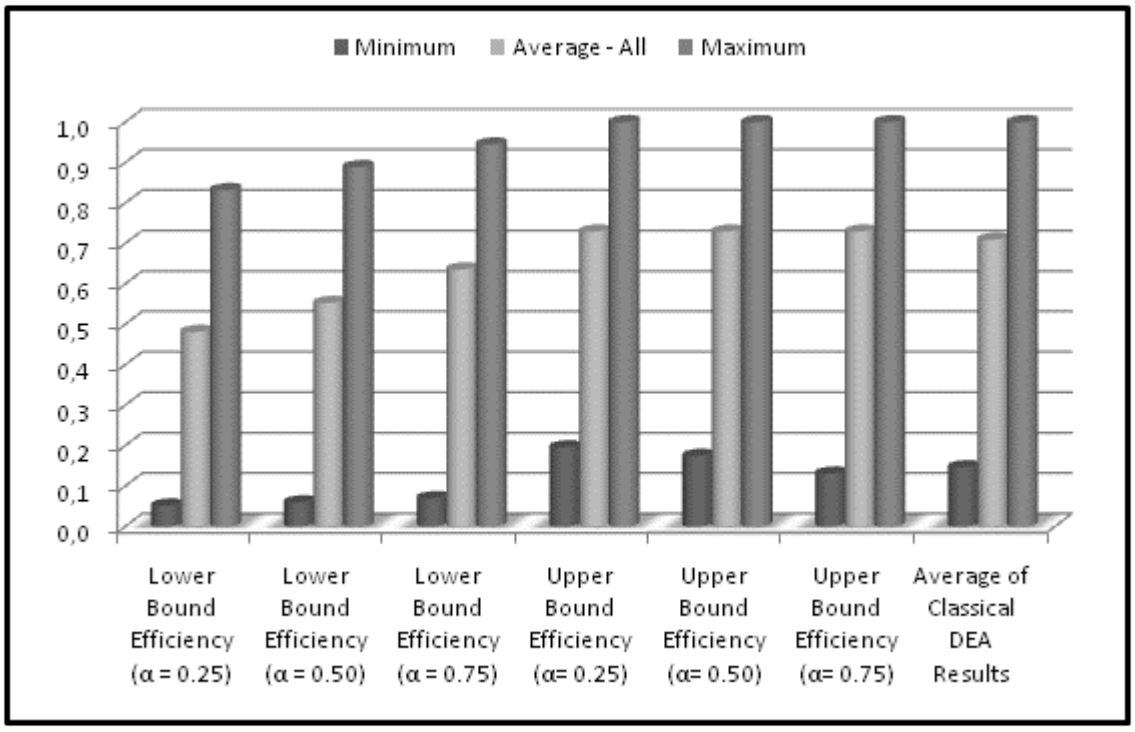


**Figure 3.9: Graphical presentation of FDEA results**

## 3.8 RANKING DMUs AND COMPARING WITH DEA

In this section DMUs (countries) will be ranked using lower bound efficiency and upper bound efficiency together by applying "Minimax Regret Approach" which is proposed by Wang, Greatbanks and Yang (2005) as explained in subsection 2.3.10.3 of this study.

To remind, the formulation of MRA was as follows.

$$min_i\{max(r_i)\} = min_i(\ max\ [max_{j\neq i}\ \{a_j^U\} - \ a_i^L\ , 0]\ )$$

In this part, the MRA will be explained by an example for α = 0.25. Consider Table 3.28. In Table 3.28, second column is lower bound efficiencies of countries, third column is upper bound efficiencies of countries, and fourth column is maximum of upper bound efficiencies excluding related country. According to the MRA, in the fourth column maximum of upper bound efficiencies excluding related country minus lower bound efficiency of related country also called maximum loss of efficiency is calculated. All of them are greater than zero. Final step is to select the minimum of maximum loss of efficiencies. In the first iteration this country is Hungary. Thus Hungary becomes most efficient country and gets number 1 in ranking.

Similar iteration goes on like this but after iteration 1; Hungary is extracted from the list. This time United States has the minimum loss among the maximum loss of efficiencies (See Table 3.29). All calculations were done for all countries for three α levels and the results are given in Table 3.31.

**Table 3.28: MRA calculation to determine the first country**

| Country | $a_i^L$ | $a_i^U$ | $max_{j \neq i}\{a_j^U\}$ | $max_{j \neq i}\{a_j^U\} - a_i^L$ |
|---|---|---|---|---|
| Argentina | 0.078 | 0.196 | 1.000 | 0.922 |
| Australia | 0.446 | 0.736 | 1.000 | 0.554 |
| Austria | 0.249 | 0.402 | 1.000 | 0.751 |
| Belgium | 0.316 | 0.454 | 1.000 | 0.684 |
| Brazil | 0.351 | 0.596 | 1.000 | 0.649 |
| Canada | 0.443 | 0.830 | 1.000 | 0.557 |
| Chile | 0.363 | 0.476 | 1.000 | 0.637 |
| China | 0.633 | 1.000 | 1.000 | 0.367 |
| Colombia | 0.174 | 0.243 | 1.000 | 0.826 |
| Czech Republic | 0.373 | 0.603 | 1.000 | 0.627 |
| Egypt | 0.678 | 1.000 | 1.000 | 0.322 |
| Finland | 0.525 | 1.000 | 1.000 | 0.475 |
| France | 0.395 | 0.683 | 1.000 | 0.605 |
| Germany | 0.398 | 0.666 | 1.000 | 0.602 |
| **Hungary** | **0.832** | **1.000** | **1.000** | **0.168** |
| India | 0.753 | 1.000 | 1.000 | 0.247 |
| Indonesia | 0.724 | 1.000 | 1.000 | 0.276 |
| Ireland | 0.332 | 0.617 | 1.000 | 0.668 |
| Israel | 0.452 | 0.627 | 1.000 | 0.548 |
| Italy | 0.488 | 1.000 | 1.000 | 0.512 |
| Japan | 0.470 | 0.635 | 1.000 | 0.530 |
| Kazakhstan | 0.151 | 0.321 | 1.000 | 0.849 |
| Korea | 0.779 | 1.000 | 1.000 | 0.221 |
| Kuwait | 0.660 | 1.000 | 1.000 | 0.340 |
| Malaysia | 0.428 | 0.724 | 1.000 | 0.572 |
| Mexico | 0.193 | 0.280 | 1.000 | 0.807 |
| Netherlands | 0.582 | 0.887 | 1.000 | 0.418 |
| Nigeria | 0.299 | 0.659 | 1.000 | 0.701 |
| Norway | 0.719 | 0.815 | 1.000 | 0.281 |
| Panama | 0.103 | 0.225 | 1.000 | 0.897 |
| Peru | 0.163 | 0.303 | 1.000 | 0.837 |
| Philippines | 0.370 | 0.586 | 1.000 | 0.630 |
| Poland | 0.287 | 0.354 | 1.000 | 0.713 |
| Russian Federation | 0.419 | 0.926 | 1.000 | 0.581 |
| Saudi Arabia | 0.712 | 1.000 | 1.000 | 0.288 |
| Singapore | 0.743 | 1.000 | 1.000 | 0.257 |
| South Africa | 0.785 | 1.000 | 1.000 | 0.215 |
| Spain | 0.636 | 0.850 | 1.000 | 0.364 |
| Sweden | 0.595 | 0.884 | 1.000 | 0.405 |
| Switzerland | 0.701 | 1.000 | 1.000 | 0.299 |
| Thailand | 0.628 | 1.000 | 1.000 | 0.372 |
| Turkey | 0.787 | 1.000 | 1.000 | 0.213 |
| Ukraine | 0.052 | 0.259 | 1.000 | 0.948 |
| United Kingdom | 0.582 | 1.000 | 1.000 | 0.418 |
| United States | 0.818 | 1.000 | 1.000 | 0.182 |

**Table 3.29: MRA calculation to determine the second country**

| **Country** | $a_i^L$ | $a_i^U$ | $max_{j \neq i}\{a_j^U\}$ | $max_{j \neq i}\{a_j^U\} - a_i^L$ |
|---|---|---|---|---|
| Argentina | 0.078 | 0.196 | 1.000 | 0.922 |
| Australia | 0.446 | 0.736 | 1.000 | 0.554 |
| Austria | 0.249 | 0.402 | 1.000 | 0.751 |
| Belgium | 0.316 | 0.454 | 1.000 | 0.684 |
| Brazil | 0.351 | 0.596 | 1.000 | 0.649 |
| Canada | 0.443 | 0.830 | 1.000 | 0.557 |
| Chile | 0.363 | 0.476 | 1.000 | 0.637 |
| China | 0.633 | 1.000 | 1.000 | 0.367 |
| Colombia | 0.174 | 0.243 | 1.000 | 0.826 |
| Czech Republic | 0.373 | 0.603 | 1.000 | 0.627 |
| Egypt | 0.678 | 1.000 | 1.000 | 0.322 |
| Finland | 0.525 | 1.000 | 1.000 | 0.475 |
| France | 0.395 | 0.683 | 1.000 | 0.605 |
| Germany | 0.398 | 0.666 | 1.000 | 0.602 |
| India | 0.753 | 1.000 | 1.000 | 0.247 |
| Indonesia | 0.724 | 1.000 | 1.000 | 0.276 |
| Ireland | 0.332 | 0.617 | 1.000 | 0.668 |
| Israel | 0.452 | 0.627 | 1.000 | 0.548 |
| Italy | 0.488 | 1.000 | 1.000 | 0.512 |
| Japan | 0.470 | 0.635 | 1.000 | 0.530 |
| Kazakhstan | 0.151 | 0.321 | 1.000 | 0.849 |
| Korea | 0.779 | 1.000 | 1.000 | 0.221 |
| Kuwait | 0.660 | 1.000 | 1.000 | 0.340 |
| Malaysia | 0.428 | 0.724 | 1.000 | 0.572 |
| Mexico | 0.193 | 0.280 | 1.000 | 0.807 |
| Netherlands | 0.582 | 0.887 | 1.000 | 0.418 |
| Nigeria | 0.299 | 0.659 | 1.000 | 0.701 |
| Norway | 0.719 | 0.815 | 1.000 | 0.281 |
| Panama | 0.103 | 0.225 | 1.000 | 0.897 |
| Peru | 0.163 | 0.303 | 1.000 | 0.837 |
| Philippines | 0.370 | 0.586 | 1.000 | 0.630 |
| Poland | 0.287 | 0.354 | 1.000 | 0.713 |
| Russian Federation | 0.419 | 0.926 | 1.000 | 0.581 |
| Saudi Arabia | 0.712 | 1.000 | 1.000 | 0.288 |
| Singapore | 0.743 | 1.000 | 1.000 | 0.257 |
| South Africa | 0.785 | 1.000 | 1.000 | 0.215 |
| Spain | 0.636 | 0.850 | 1.000 | 0.364 |
| Sweden | 0.595 | 0.884 | 1.000 | 0.405 |
| Switzerland | 0.701 | 1.000 | 1.000 | 0.299 |
| Thailand | 0.628 | 1.000 | 1.000 | 0.372 |
| Turkey | 0.787 | 1.000 | 1.000 | 0.213 |
| Ukraine | 0.052 | 0.259 | 1.000 | 0.948 |
| United Kingdom | 0.582 | 1.000 | 1.000 | 0.418 |
| United States | 0.818 | 1.000 | 1.000 | 0.182 |

In Table 3.31, beside FDEA rankings, the ranking for the average value of three years' overall efficiency score is given. When a country is efficient in classical DEA the sign

"-" is used in the ranking column. To compare fuzzy DEA results with overall efficiency result of classical DEA is reasonable since they both use CRR logic. From Table 3.31 some implications can be stated as follows:

- There is not any such difference in ranking among Fuzzy Data Envelopment results for three α levels. However, generally classical DEA ranking is very close to FDEA ranking except some countries.
- The first 7 countries in FDEA ranking for three α levels are the same with different combinations. Also these 7 countries were found efficient in classical DEA models for three years. These countries are Hungary, United States, South Africa, Turkey, Korea, Singapore and India.
- Other countries found efficient in classical DEA models in 2007, 2008 and 2009 were Saudi Arabia, Switzerland, China and United Kingdom. When the ranks of these countries in FDEA models are investigated, it is seen that Saudi Arabia has rank 9-10, Switzerland has rank 10-11, China has rank 13-14-15, and United Kingdom has rank 15-16-17.
- 13 countries have the same ranking position for all α levels in FDEA model. 9 of them are in rank between 37 and 45. These countries are Belgium, Austria, Mexico, Colombia, Kazakhstan, Argentina, Peru, Panama and Ukraine.
- Three countries have the same rank in all four models. These countries and their ranks are: Austria – 38; Mexico – 39; Ukraine – 45.
- When Austria and Mexico which are the countries that have the same ranks in all four models are investigated in detail the order of lower and upper bound efficiencies for three α levels and average of classical DEA results differs.
- Austria and Mexico has the $38^{th}$ and $39^{th}$ ranks respectively with the efficiency scores in different models as follows:

**Table 3.30: Comparison of efficiency scores of two special countries**

| Country | Lower Bound Efficiency (α = 0.25) | Upper Bound Efficiency (α= 0.25) | Lower Bound Efficiency (α = 0.50) | Upper Bound Efficiency (α= 0.50) | Lower Bound Efficiency (α = 0.75) | Upper Bound Efficiency (α= 0.75) | Average of Classical DEA Results |
|---|---|---|---|---|---|---|---|
| Austria | 0.249 | 0.402 | 0.289 | 0.402 | 0.339 | 0.399 | 0.376 |
| Mexico | 0.193 | 0.280 | 0.217 | 0.287 | 0.254 | 0.294 | 0.315 |

**Table 3.31: Ranking in classical DEA and fuzzy DEA**

| Country | Stage of Development | Classical DEA | Fuzzy DEA $\alpha = 0.25$ | Fuzzy DEA $\alpha = 0.50$ | Fuzzy DEA $\alpha = 0.75$ |
|---|---|---|---|---|---|
| Hungary | Developed | - | 1 | 1 | 1 |
| United States | Developed | - | 2 | 2 | 2 |
| South Africa | Developing | - | 4 | 4 | 3 |
| Turkey | Developing | - | 3 | 3 | 4 |
| Korea | Developed | - | 5 | 5 | 5 |
| Singapore | Developed | - | 7 | 7 | 6 |
| India | Developing | - | 6 | 6 | 7 |
| Indonesia | Developing | 14 | 8 | 8 | 8 |
| Egypt | Developing | 15 | 12 | 11 | 9 |
| Saudi Arabia | Developed | - | 10 | 9 | 10 |
| Switzerland | Developed | - | 11 | 10 | 11 |
| Kuwait | Developed | 12 | 13 | 13 | 12 |
| China | Developing | - | 15 | 14 | 13 |
| Thailand | Developing | 13 | 16 | 15 | 14 |
| United Kingdom | Developed | - | 17 | 16 | 15 |
| Norway | Developed | 17 | 9 | 12 | 16 |
| Finland | Developed | 21 | 20 | 19 | 17 |
| Italy | Developed | 19 | 21 | 20 | 18 |
| Spain | Developed | 16 | 14 | 17 | 19 |
| Sweden | Developed | 18 | 18 | 18 | 20 |
| Netherlands | Developed | 20 | 19 | 21 | 21 |
| Russian Federation | Developing | 23 | 24 | 22 | 22 |
| Canada | Developed | 22 | 22 | 23 | 23 |
| Australia | Developed | 24 | 23 | 24 | 24 |
| Germany | Developed | 28 | 29 | 27 | 25 |
| Nigeria | Developing | 32 | 34 | 30 | 26 |
| France | Developed | 26 | 28 | 28 | 27 |
| Japan | Developed | 25 | 25 | 25 | 28 |
| Malaysia | Developing | 27 | 26 | 29 | 29 |
| Israel | Developed | 29 | 27 | 26 | 30 |
| Czech Republic | Developed | 33 | 30 | 31 | 31 |
| Brazil | Developing | 30 | 33 | 33 | 32 |
| Ireland | Developed | 34 | 35 | 34 | 33 |
| Philippines | Developing | 31 | 31 | 32 | 34 |
| Chile | Developing | 35 | 32 | 36 | 35 |
| Poland | Developed | 37 | 36 | 35 | 36 |
| Belgium | Developed | 36 | 37 | 37 | 37 |
| Austria | Developed | 38 | 38 | 38 | 38 |
| Mexico | Developing | 39 | 39 | 39 | 39 |
| Colombia | Developing | 42 | 40 | 40 | 40 |
| Kazakhstan | Developing | 40 | 41 | 41 | 41 |
| Argentina | Developing | 44 | 42 | 42 | 42 |
| Peru | Developing | 41 | 43 | 43 | 43 |
| Panama | Developing | 43 | 44 | 44 | 44 |
| Ukraine | Developing | 45 | 45 | 45 | 45 |

The graphical representation of efficiency scores of Austria and Mexico are given in Figure 3.10 and Figure 3.11 respectively. Similar figures that show lower bound efficiencies, upper bound efficiencies and average of classical DEA overall efficiency scores of three years are given for all countries in Appendix 3.

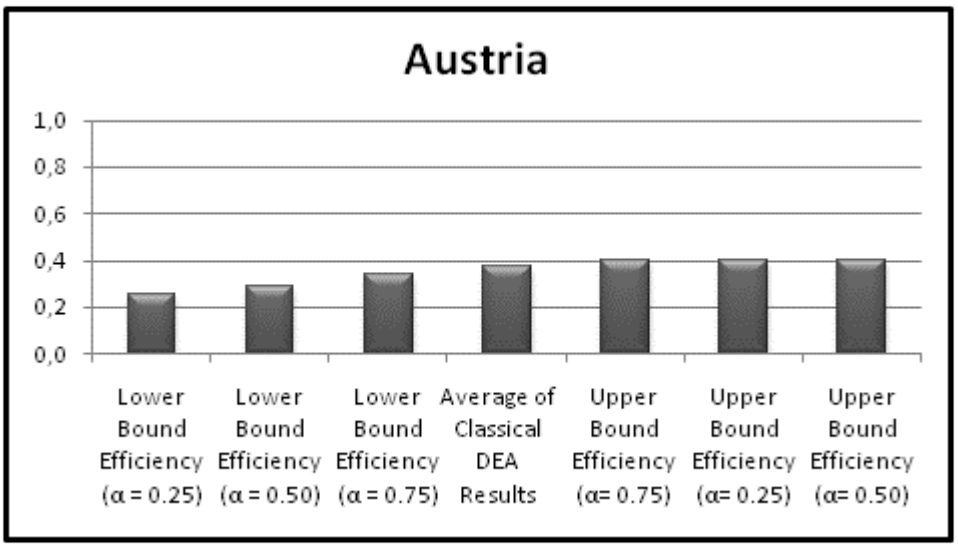


**Figure 3.10: Efficiency scores for Austria**

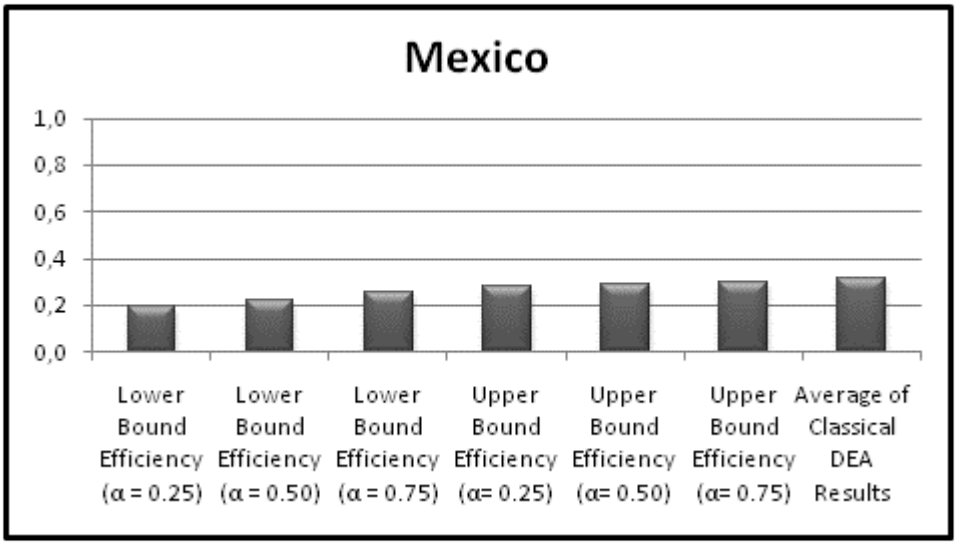


**Figure 3.11: Efficiency scores for Mexico**

# 4. CONCLUSION AND FURTHER RESEARCH

Value traded in 2009 in the world was about 80 trillion USD while total GDP of the world in 2009 was about 56 trillion USD. This is one of the reasons why stock markets are important for an economy. All countries are searching ways to improve their stock markets. A way for countries to examine the comparative situation of their stock markets can be to analyze their efficiency level. By analyzing efficiency, countries can evaluate how they use their potential. The aim of this study was to examine the efficiency of stock markets with a country-based approach by using classical and fuzzy Data Envelopment Analysis methods. Thus, it is expected that decision makers can see their efficiency level and develop policies and solutions if their stock markets are not efficient.

Efficiency can be defined as the degree of realization of the stock market objectives defined for a country as a result of the activities realized for reaching these goals. The methods for measuring efficiency can be classified under there headings: the ratio analysis, parametric methods and non-parametric methods. In this study Data Envelopment Analysis (DEA) which is one of the non-parametric methods is used as a method for evaluating stock market efficiencies of countries.

Data Envelopment Analysis is a relatively new, linear programming based, data oriented approach which is directed to frontiers rather than central tendencies for evaluating the performance or efficiencies of a set of peer entities called Decision Making Units (DMUs) which convert multiple inputs into multiple outputs (Cooper 2004).

DEA has some strengths compared to other methods such as does not need to have specific functional forms of relations between inputs and outputs, a large number of inputs and outputs can be considered at the same time in DEA and the weights of inputs and outputs are determined by the model.

DEA is used in different areas to evaluate efficiency such as banking, health, and education. However, during the literature survey, any internationally cited article is found which examines the efficiency of stock markets by using DEA method.

There are four stages in a DEA application:

a) Determination of DMUs to be analyzed,
b) Determination of appropriate inputs and outputs for the model,
c) Determination of DEA model,
d) Evaluation of results.

In this study, 45 countries of which 25 are developed countries and 20 are developing countries determined as DMUs. The 45 countries represent 90 percent of whole world in terms of market capitalization value and 95 percent of the whole world in terms of trading volume.

Determination of appropriate inputs and outputs for the model was done by the help of literature survey about the determinants of the stock market development. Considering literature survey and special characteristics of DEA application, input and output variables were determined.

Inputs variables in DEA models in this study are

- Gross Domestic Product (GDP),
- GDP per capita and,

the first five pillars of Financial Development Report of World Bank namely;

- Institutional environment,
- Business environment,
- Financial stability,
- Banking financial services,
- Non-banking financial services.

Outputs variables in DEA models in this study are

- Market capitalization value in billion USD (the sum of product of stock price by stock number),
- Value traded in billion USD (the value of buying or selling through year),
- Turnover ratio (division of the value traded to average market capitalization).

Classical and fuzzy Data Envelopment Analysis methods were used in this study to determine the relative efficiency of the stock markets. In classical DEA application output-oriented CCR and BCC models were used. The efficiency scores in fuzzy DEA is found and ranked by Wang et al. (2005) approach which is proposed for interval values and similar to CCR. The comparison of efficiency scores of classical DEA and fuzzy DEA were done by using the average of CCR model scores of classical DEA.

In addition efficiency scores; in classical DEA models the change in efficiency by time which is measured by using Malmquist Total Productivity Index and in fuzzy DEA models the ranks of the countries which are found by Minimax Regret Approach in terms of efficiency is evaluated.

Classical DEA was used to obtain efficiency scores for three years: 2007, 2008 and 2009. In fuzzy DEA, the values of 2007, 2008 and 2009 were used to get triangular fuzzy numbers and then lower and upper bounds for three α-cut levels (0.25, 0.50, and 0.75).

The models in classical DEA are solved by Deap Version 2.1, the FDEA model in solved by the help of Microsoft Excel 2007 Solver Add-in formed by Dr. İsmail Şafak.

Some important findings in the study can be summarized as follows:

Implications related to market indicators and their relations:

- In 2007, about 45 percent of all value traded in the world and 33 percent of world's total market capitalization value belongs to United States. 15 countries that have the highest values in value traded have 94 percent share in value traded and 85 percent share in market capitalization.

- In 2008, about 47 percent of all value traded in the world and 36.5 percent of world's market capitalization value belongs to United States. 15 countries that have the highest values in value traded have 94 percent share in value traded and 88 percent share in market capitalization.

- In 2009, about 60 percent of all value traded in the world and 36.5 percent of world's market capitalization value belongs to United States. It was 47 percent for value traded in year 2008. 15 countries that have the highest values in value traded have 94 percent share in value traded and 88 percent share in market capitalization.

- The data above imply that only a limited number of countries are dominating the stock markets and the most important stock markets are the stock markets of United States with about 50 percent share in value traded.

- Turkey was found efficient in all three years in classical DEA but the share of Turkey in total value traded is about only 0.32 percent. This implies that Turkey is efficient but a small stock market.

- Value traded and market capitalization is highly correlated with each other whereas turnover ratio has a medium and nearly same correlation with the other two output variables.

- Value traded and market capitalization is highly correlated with GDP (about 0.95) but not with GDP per capita (about 0.20). As seen in literature survey most of the studies take market capitalization to GDP and value traded to GDP as indicators of the stock market development but the correlations among GDP, value traded and market capitalization is considered this approach may need to be revised.

Implications related to classical DEA:

- In classical DEA for 2007; 16 countries were overall efficient, 28 countries were pure technical efficient and 17 countries were scale efficient. In classical DEA for 2008, 17 countries are overall efficient, 26 countries are pure technical efficient and 17 countries are scale efficient. In classical DEA for 2009 13 countries are overall efficient, 21 countries are pure technical efficient and 15 countries are scale efficient. Number of

efficient countries in all three type of efficiency is the minumum in year 2009. This result may depend on changes in portfolio investment policies after global financial crisis. Investors are maybe becoming more risk-averse and investing their money to safe markets.

- In classical DEA, average overall efficiency is 0.73 in 2007, 0.74 in 2008 and 0.66 in 2009; average pure technical efficiency is 0.89 in 2007, 0.88 in 2008 and 0.80 in 2009; average scale efficiency is 0.73 in 2007, 0.84 in 2008 and 0.84 in 2009. Average overall efficiency and average pure technical efficiency is decreasing from 2007 to 2009 whereas average scale efficiency is increasing in that period.

- It can be interpreted from average effiency scores that overall efficiency is highly affected from scale efficiency in 2007 and from pure technical efficiency in 2009.

- In classical DEA, average overall efficiency is 0.80 in 2007, 0.83 in 2008 and 0.73 in 2009 for developed countries and 0.64 in 2007, 0.61 in 2008 and 0.58 in 2009 for developing countries. These results show that developed countries have greater overall efficiency scores than developing countries on the average.

- When the reference tables of classical DEA in 2007, 2008 and 2009 are evaluated together it can be stated countries that referenced most by other countries are South Africa, Korea, Switzerland, Finland and United States.

- According to the classical DEA overall efficiency results the number of countries found efficient in all three years is 11. These countries are Hungary, Korea, Saudi Arabia, Singapore, Switzerland, United Kingdom, United States, China, India, South Africa, and Turkey.

- According to the classical DEA overall efficiency results the number of countries found efficient in any two years is 6. These countries are Italy, Finland, Kuwait, Indonesia, Egypt, and Thailand.

- According to the classical DEA overall efficiency results the number of countries found efficient in only one of three years is 1. This country is Netherlands.

- According to the classical DEA overall efficiency results the number of countries found inefficient in all three years is 27. These countries are Norway, Canada, Australia, Sweden, Spain, France, Israel, Japan, Germany, Belgium, Czech Republic, Poland, Ireland, Austria, Russian Federation, Brazil, Malaysia, Philippines, Chile, Mexico, Nigeria, Colombia, Kazakhstan, Peru, Panama, Argentina, and Ukraine.

- The average of Total Factor Productivity Index is 0.953 which indicates a decrease in 2008 and 2009 in the average with respect to 2007. According to the average of Total Factor Productivity Index 16 countries has an index value which is greater than 1, these countries are Thailand, Russian Federation, Australia, United States, Mexico, Hungary, Brazil, Korea, Chile, Indonesia, Colombia, Canada, Turkey, China, India and United Kingdom. 10 of these 16 countries are developing impliying that developing countries have gained more importance in the period 2007-2009. When that global financial crisis which reached to peak in 2008 is considered, this result is meaningful.

Implications related to fuzzy DEA and comparison with classical DEA:

- In fuzzy DEA average of lower bound efficiencies of 45 countries for $\alpha = 0.25$, 0.50 and 0.75 are 0.481, 0.553 and 0.636 respectively. Average of upper bound efficiencies of 45 countries are 0.730 for all $\alpha$ levels. When it is considered that in classical DEA, average overall efficiencies were 0.73 in 2007, 0.74 in 2008 and 0.66 in 2009, it can be stated that on the average upper bound efficiency scores of fuzzy DEA is closer to classical DEA scores than lower bound efficiency scores.

- Another implication from fuzzy DEA efficiency scores is about minimum absolute difference to average of 2007, 2008 and 2009 overall efficiency scores obtained by using classical DEA. 26 countries have the minimum difference to average of 2007, 2008 and 2009 overall efficiency scores for upper bound efficiency of $\alpha = 0.75$ of; 9 countries for upper bound efficiency of $\alpha = 0.25$; 5 countries for lower bound efficiency of $\alpha = 0.75$ and 5 countries for upper bound efficiency of $\alpha = 0.50$. Thus, it can be concluded that among $\alpha$ levels, $\alpha=0.75$ in upper bound efficiency produdes the closest scores to classical DEA.

- When the number of efficient countries is taken into account, it can be stated that upper bound efficiency in FDEA produces generally better efficiency scores as compared with classical DEA.

- According to the Minimax Regret Approach, there is not any such difference in ranking among Fuzzy Data Envelopment results for three α levels. However, generally classical DEA ranking is very close to FDEA ranking except some countries.

- The first 7 countries in FDEA ranking for three α levels are the same with different combinations. Also these 7 countries were found efficient in classical DEA models for three years. These countries are Hungary, United States, South Africa, Turkey, Korea, Singapore and India.

- Other countries found efficient in classical DEA models in 2007, 2008 and 2009 were Saudi Arabia, Switzerland, China and United Kingdom. When the ranks of these countries in FDEA models are investigated, it is seen that Saudi Arabia has rank 9-10, Switzerland has rank 10-11, China has rank 13-14-15, and United Kingdom has rank 15-16-17.

- 13 countries have the same ranking position for all α levels in FDEA model. 9 of them are in rank between 37 and 45. These countries are Belgium, Austria, Mexico, Colombia, Kazakhstan, Argentina, Peru, Panama and Ukraine.

- There is a pattern when the ranking of efficiency scores in lower bound, upper bound and average of classical DEA overall efficiency when all countries examined. After efficiency scores are ranked from the smallest to the biggest, it is seen that they follow a pattern with little changes for some countries. The ranking is like that; lower bound efficiency for α=0.25, lower bound efficiency for α=0.50, lower bound efficiency for α=0.75, average of classical DEA overall efficiency, upper bound efficiency for α=0.25, upper bound efficiency for α=0.50 and upper bound efficiency for α=0.75.

This study has unavoidable limitations and several important issues that warrant further research. Lack of another study researching the same issue is the most important problem creating comparison difficulty. Input and output variables are selected with a highly subjective approach. Most of input variables are based on pillars of Financial

Development Report of World Economic Forum and the subjects evaluated in this report is not simply measuring issues. There is no absolute way to evaluate subjects so the report methodology and its weighting policy of pillars are subjective in it. Another problem is that the methods to evaluate the size of stock markets are not reliable. This prevents doing logical comparisons between stock markets and evaluating efficiency scores as considering size. Additionally, this study has limitation about the period examined. Only three years was studied and maybe this is not enough to check the robustness of the model and results. This study gives information about the inefficient countries but not the reason of inefficiency.

Regarding future research, researchers can research the same subject for broader periods with different input and output variables. They also study the reasons of inefficiency and can develop a model explaining the factors with their degree of influence.

It is expected that this study can supply a different point of view and useful guidance for the governments and stock exchanges to compare themselves with other countries.

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# APPENDICES

## APPENDIX A: Total Factor Productivity (TFP) Index and Overall (CCR) Efficiency Score Graphics of Countries for 2007-2009

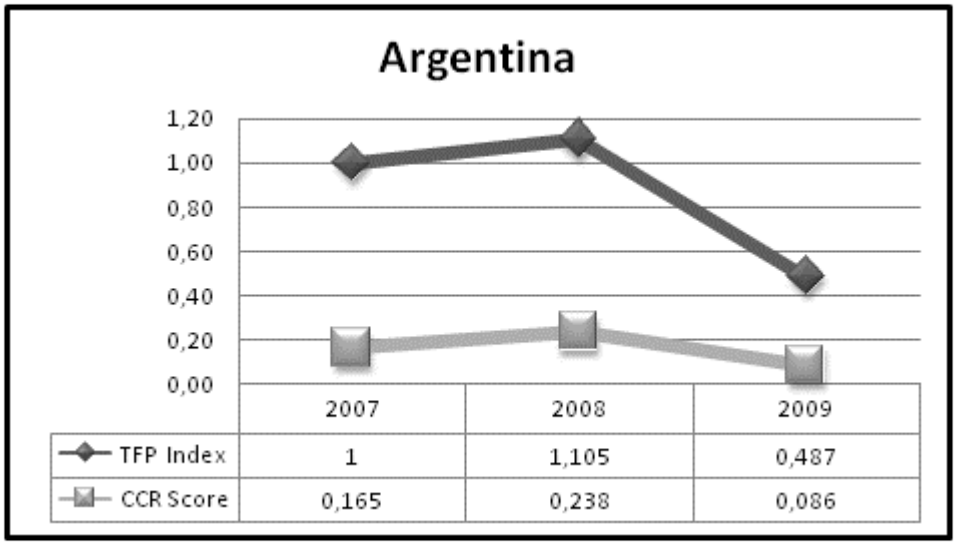


**Figure A.1: TFP and CCR Scores for Argentina**

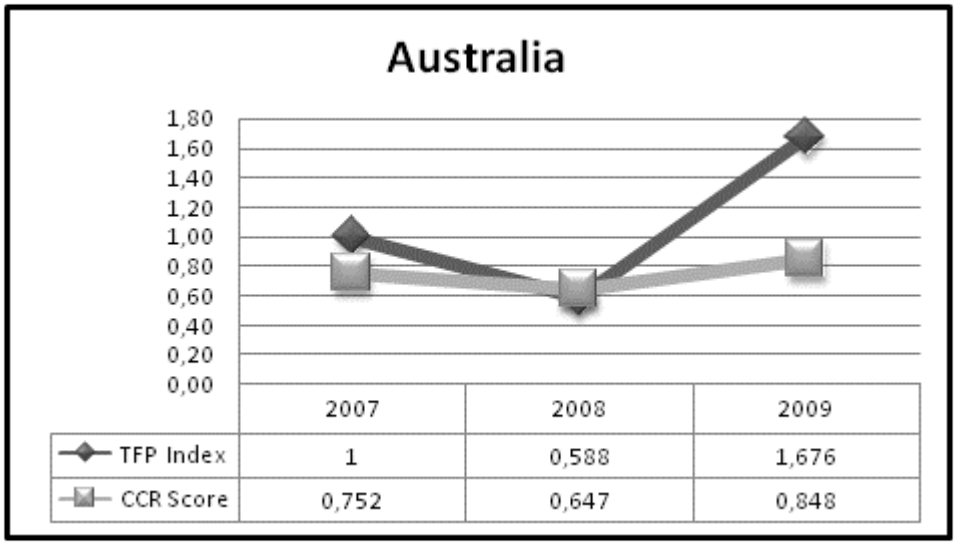


**Figure A.2: TFP and CCR Scores for Australia**

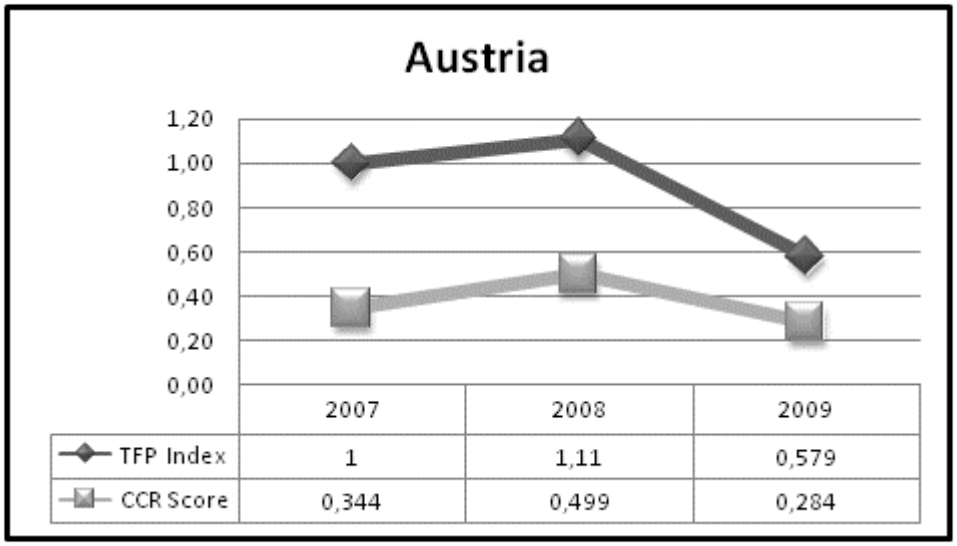


**Figure A.3: TFP and CCR Scores for Austria**

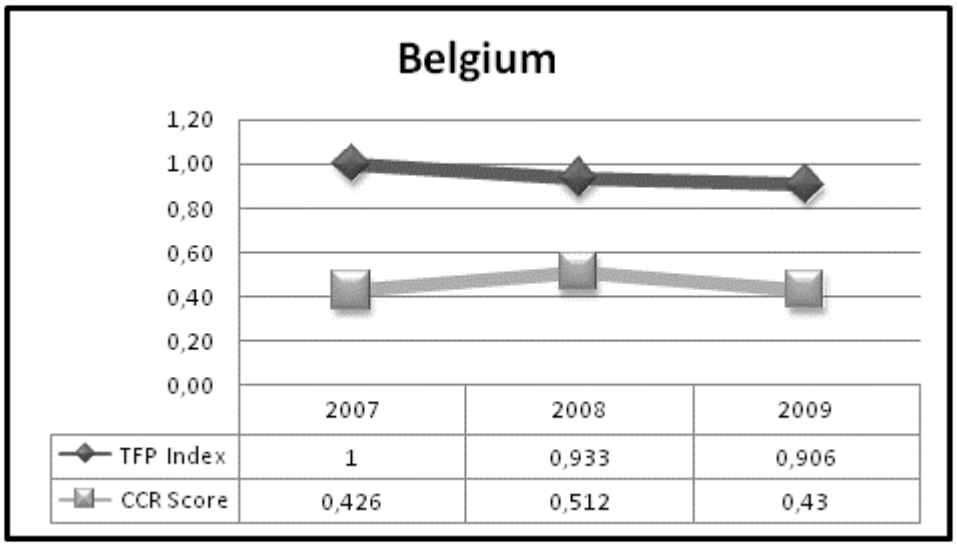


**Figure A.4: TFP and CCR Scores for Belgium**

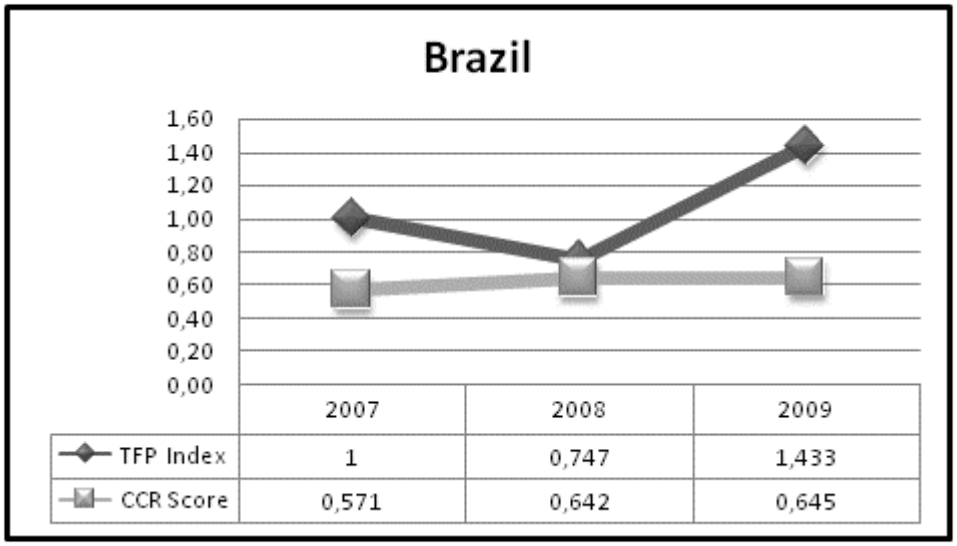


**Figure A.5: TFP and CCR Scores for Brazil**

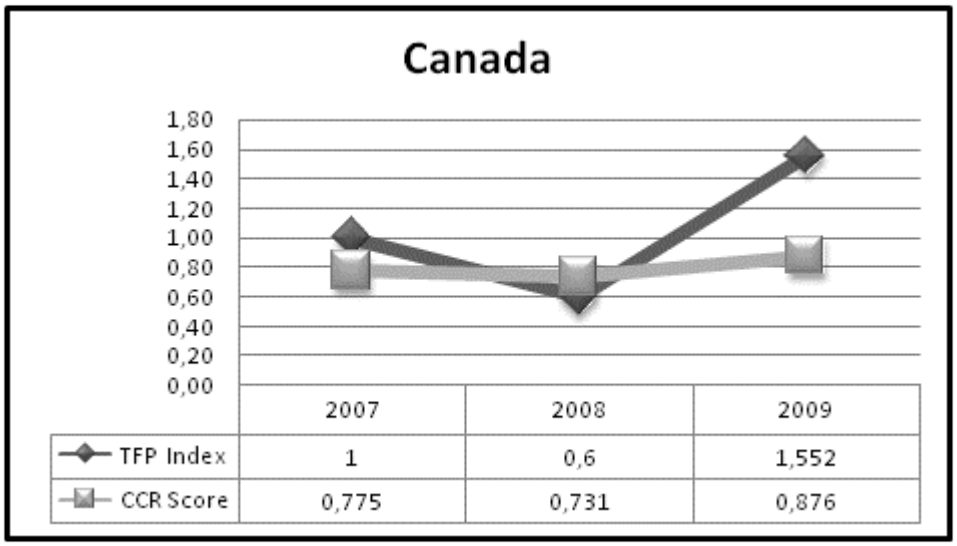


**Figure A.6: TFP and CCR Scores for Canada**

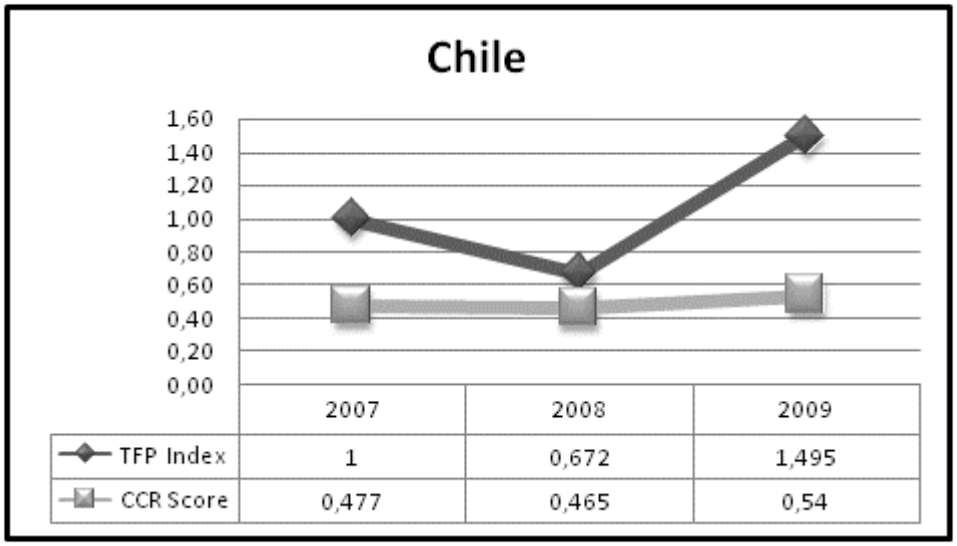


**Figure A.7: TFP and CCR Scores for Chile**

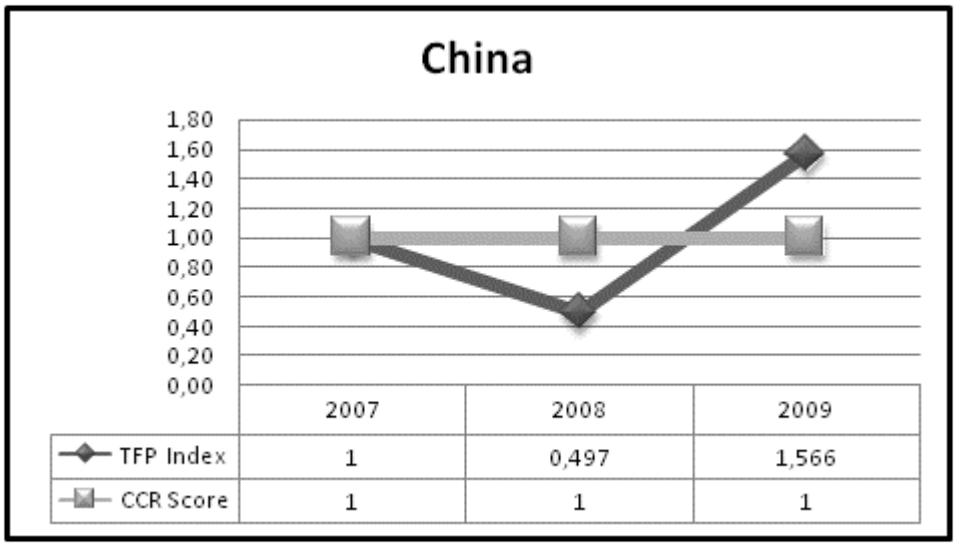


**Figure A.8: TFP and CCR Scores for China**

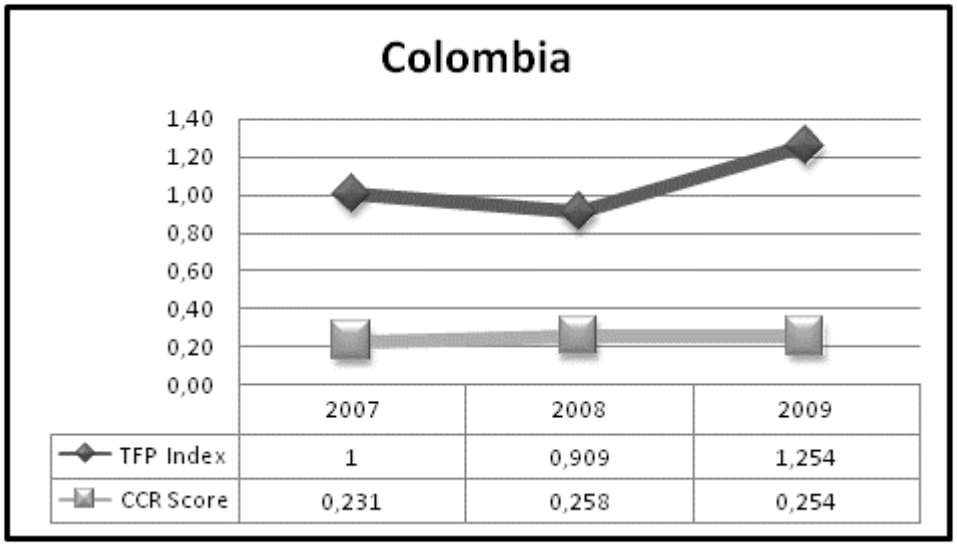


**Figure A.9: TFP and CCR Scores for Colombia**

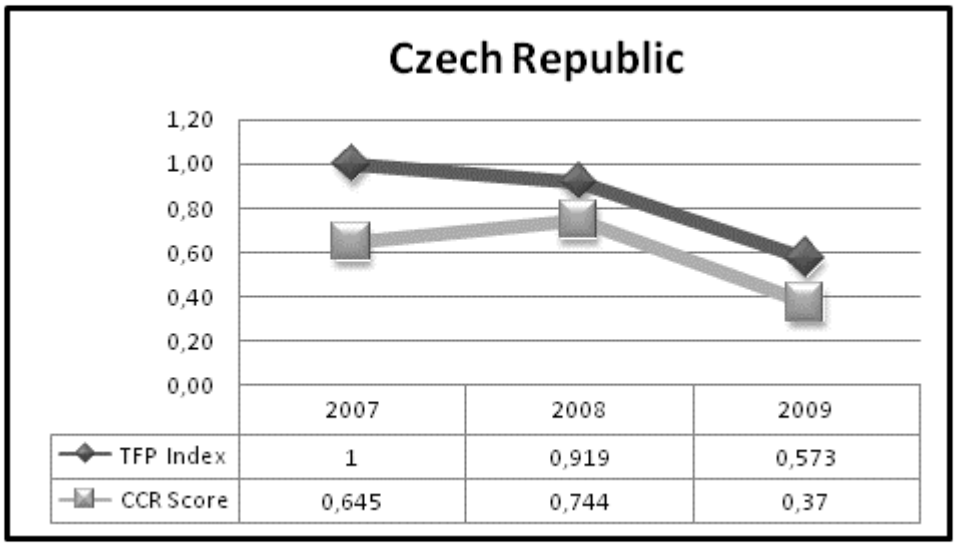


**Figure A.10: TFP and CCR Scores for Czech Republic**

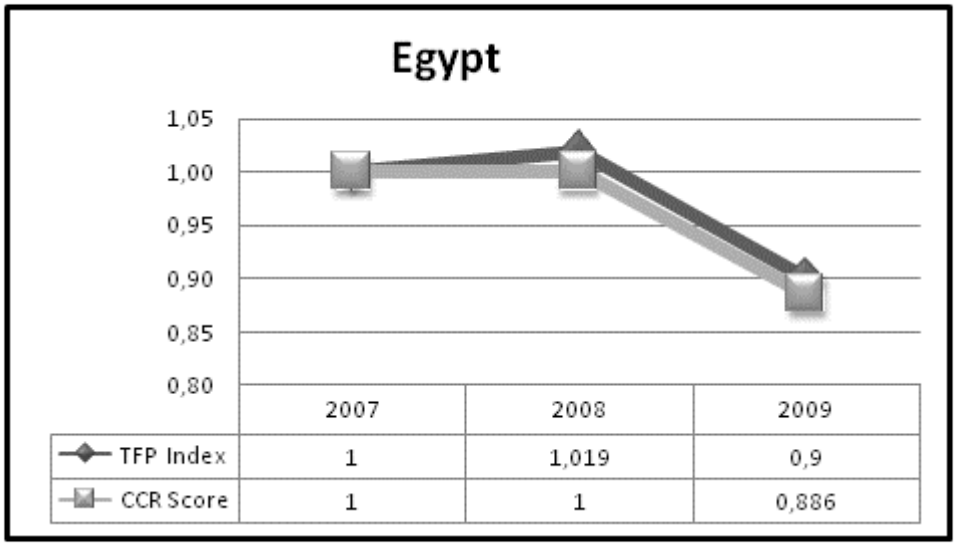


**Figure A.11: TFP and CCR Scores for Egypt**

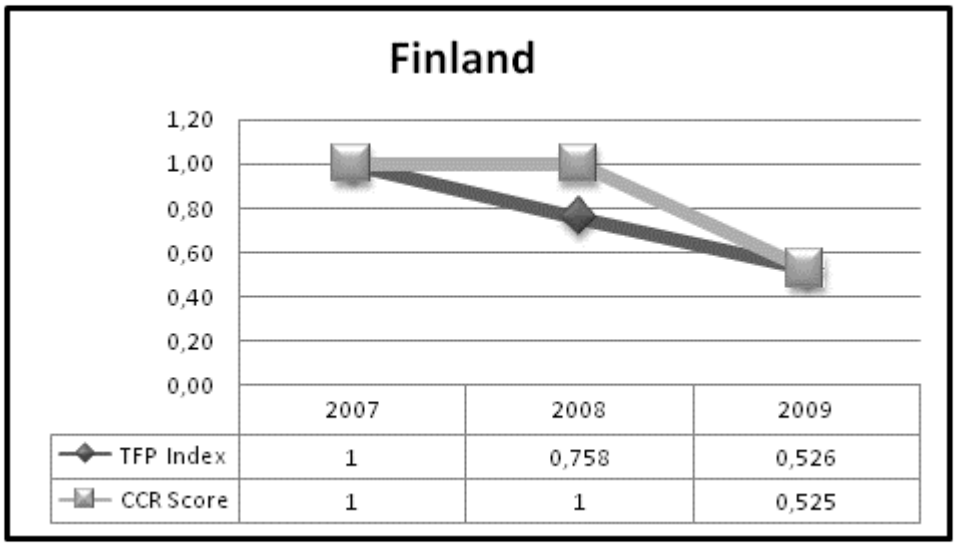


**Figure A.12: TFP and CCR Scores for Finland**

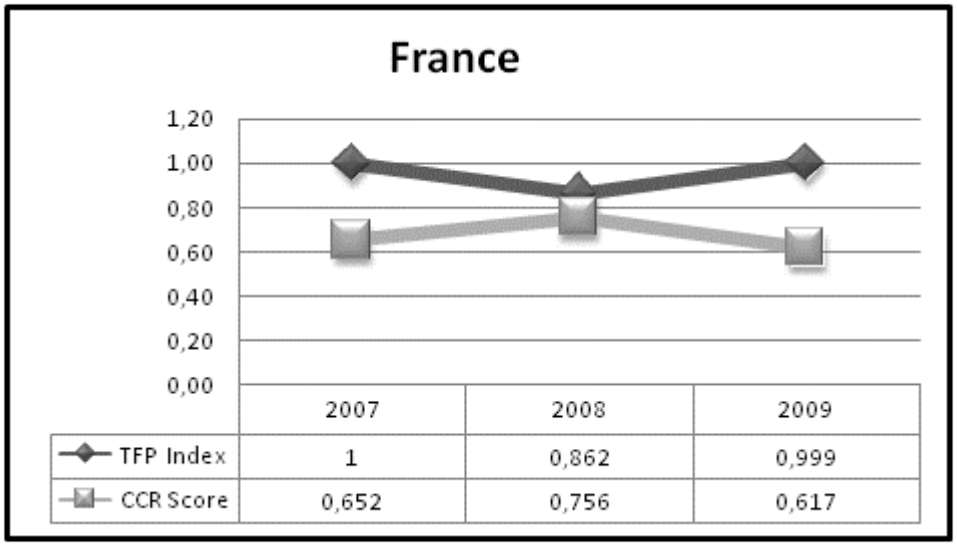


**Figure A.13: TFP and CCR Scores for France**

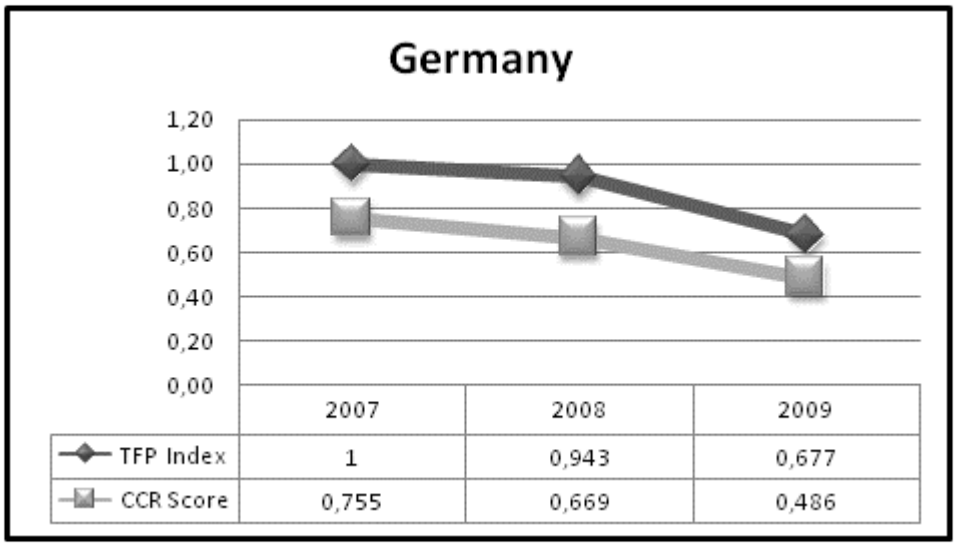


**Figure A.14: TFP and CCR Scores for Germany**

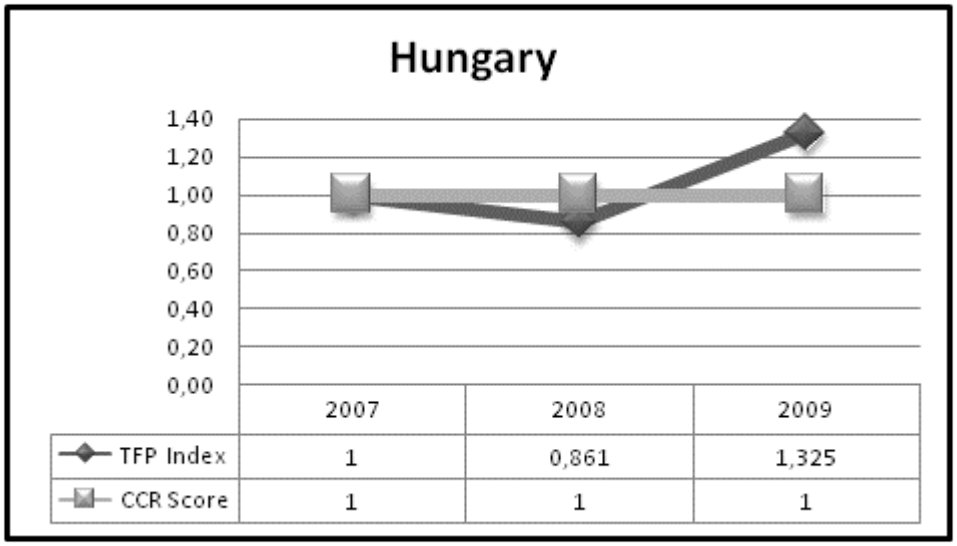


**Figure A.15: TFP and CCR Scores for Hungary**

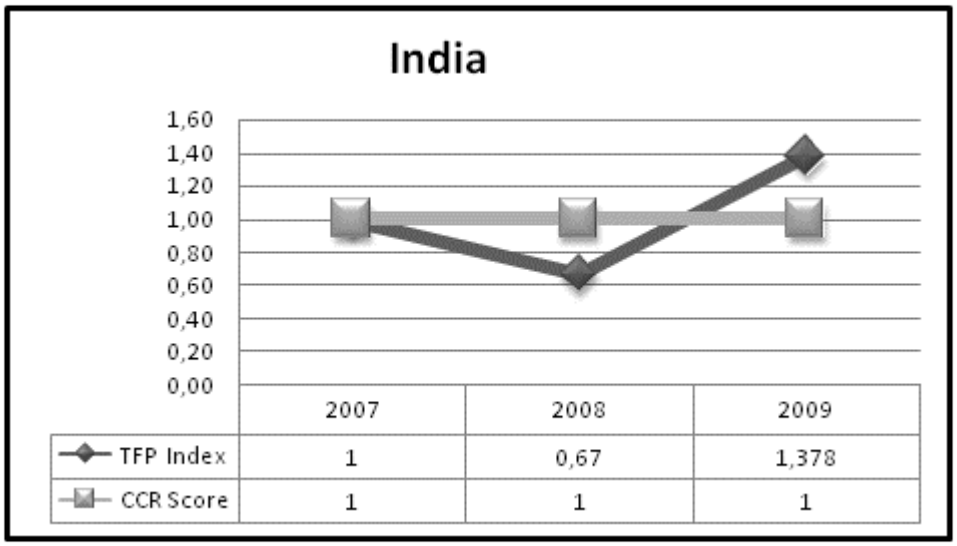


**Figure A.16: TFP and CCR Scores for India**

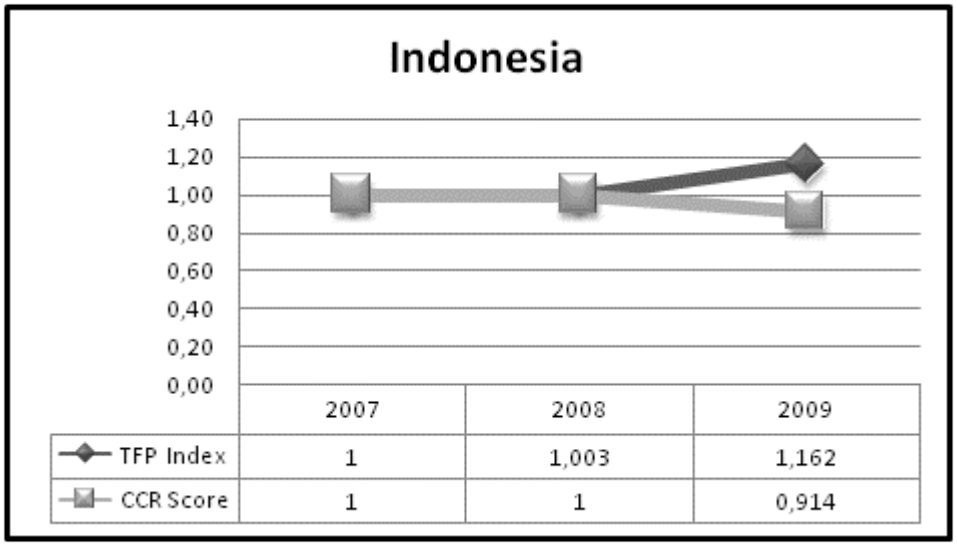


**Figure A.17: TFP and CCR Scores for Indonesia**

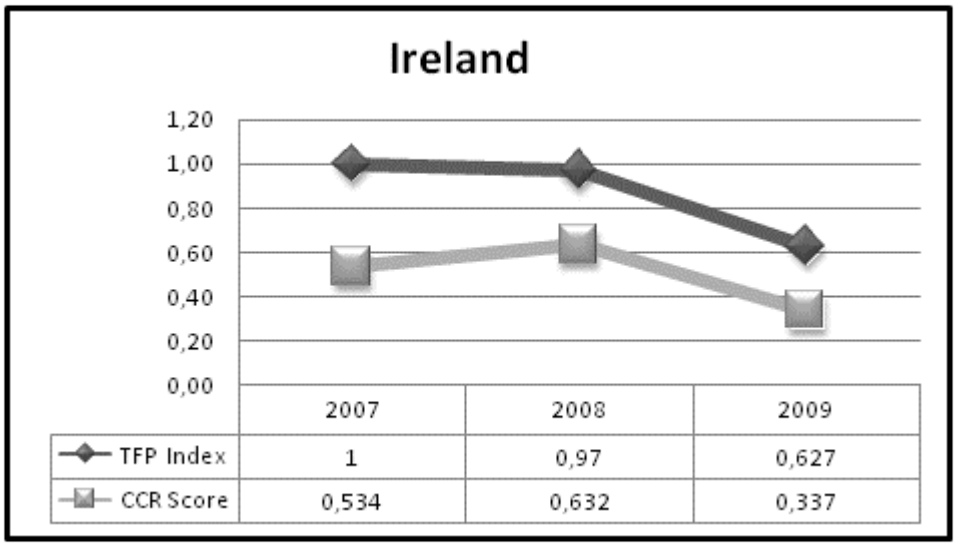


**Figure A.18: TFP and CCR Scores for Ireland**

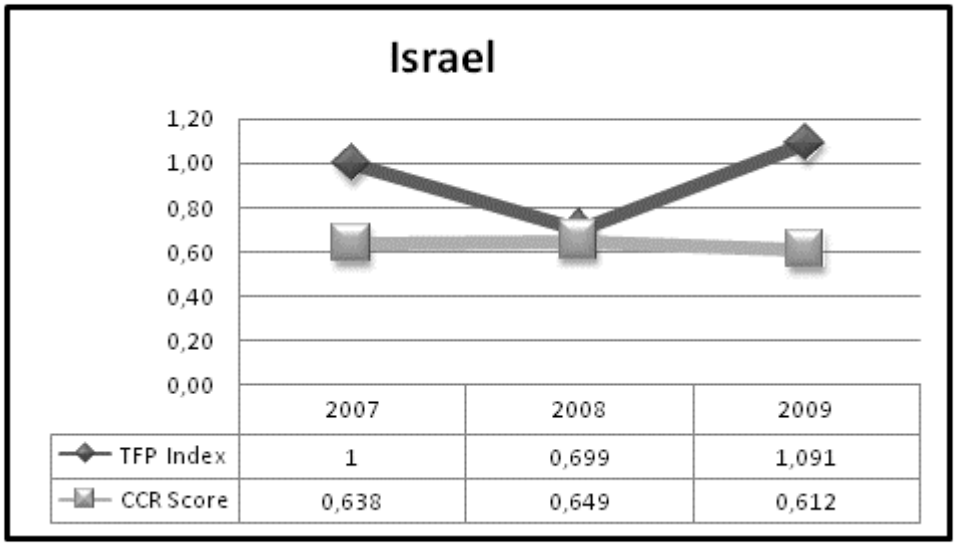


**Figure A.19: TFP and CCR Scores for Israel**

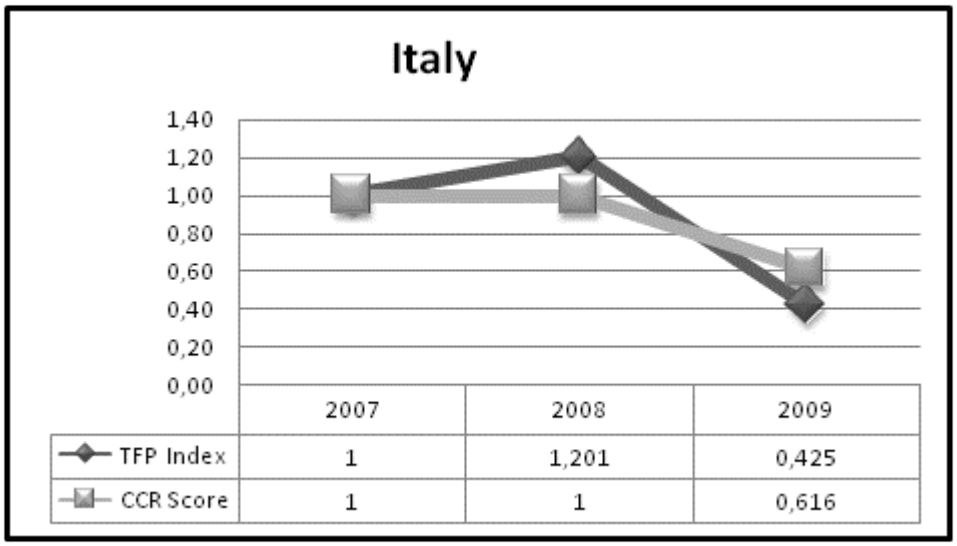


**Figure A.20: TFP and CCR Scores for Italy**

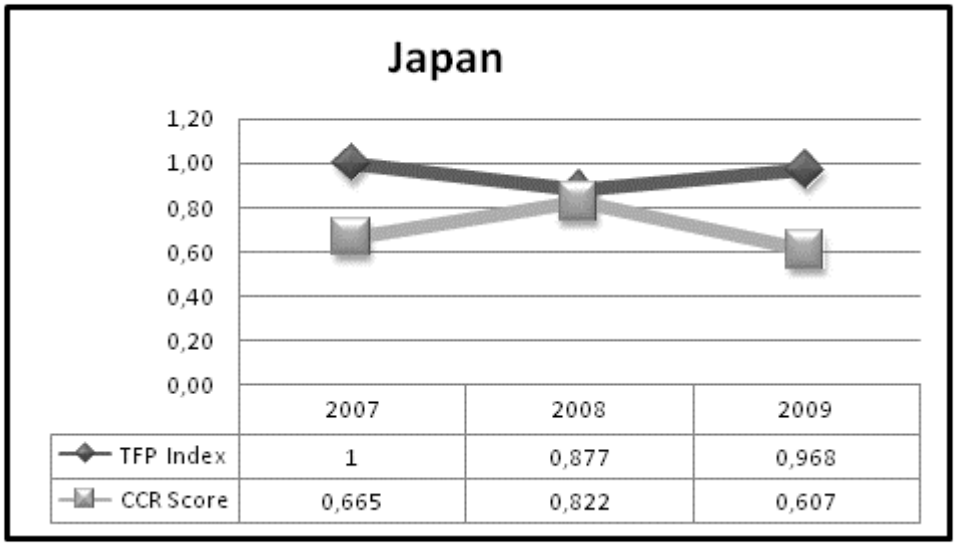


**Figure A.21: TFP and CCR Scores for Japan**

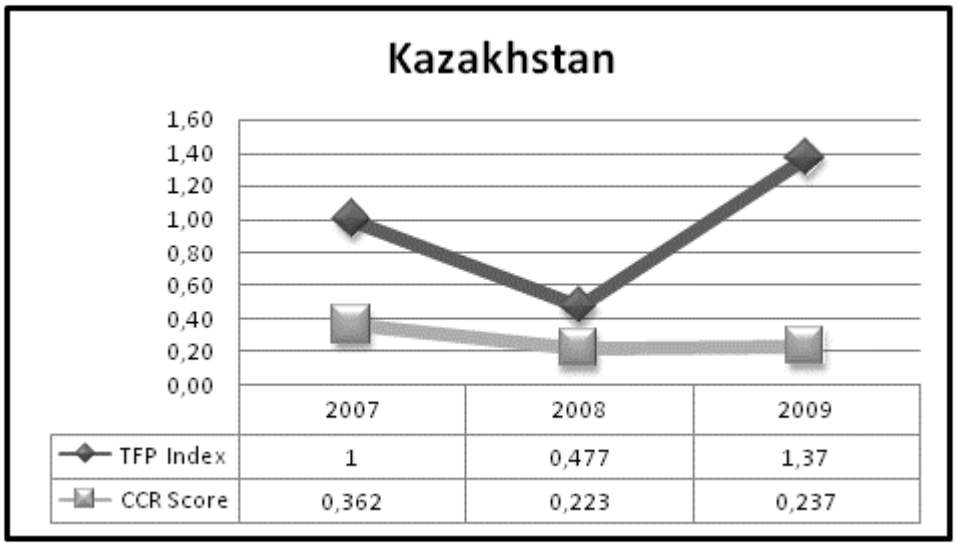


**Figure A.22: TFP and CCR Scores for Kazakhstan**

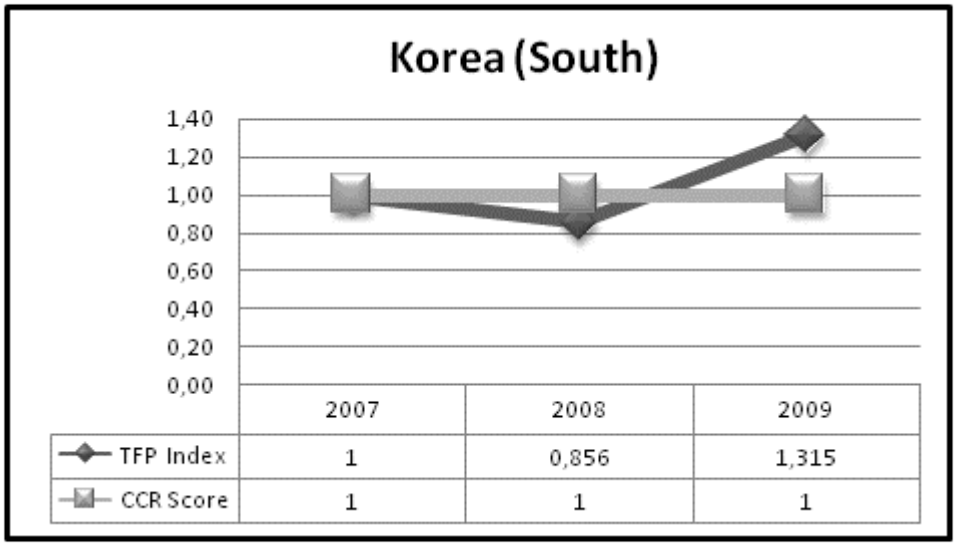


**Figure A.23: TFP and CCR Scores for Korea (South)**

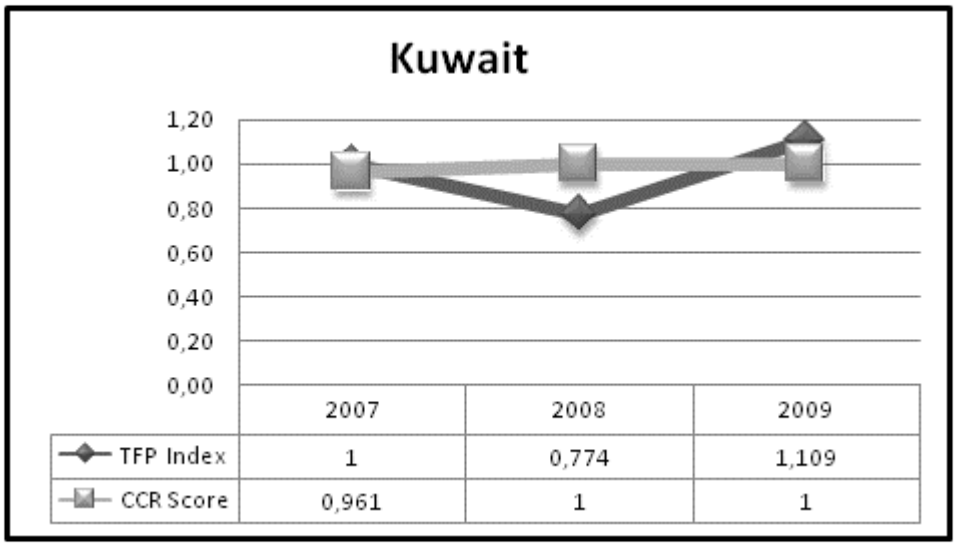


**Figure A.24: TFP and CCR Scores for Kuwait**

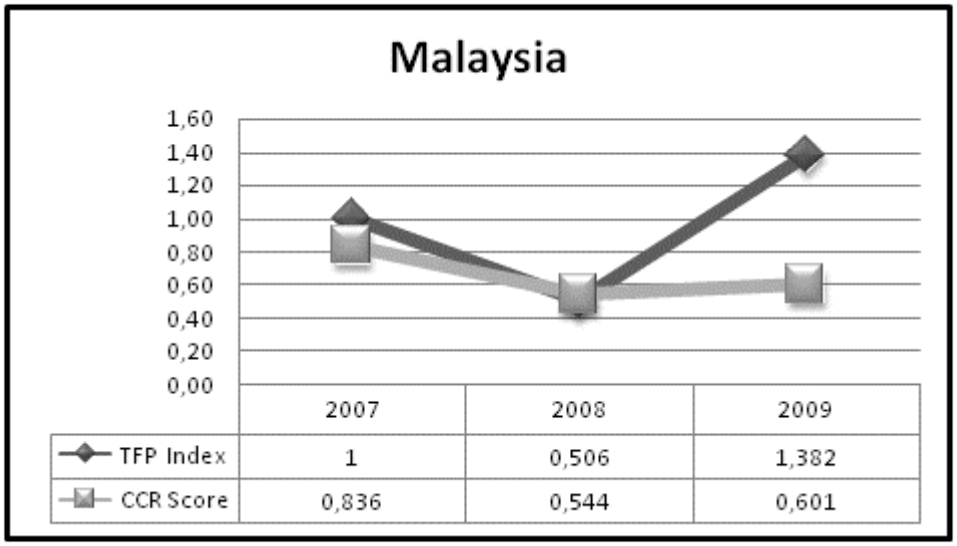


**Figure A.25: TFP and CCR Scores for Malaysia**

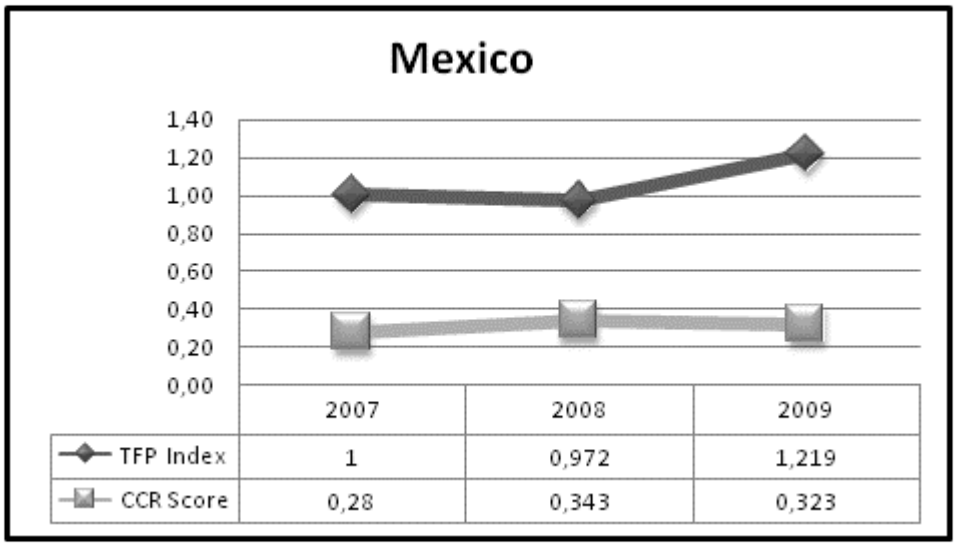


**Figure A.26: TFP and CCR Scores for Mexico**

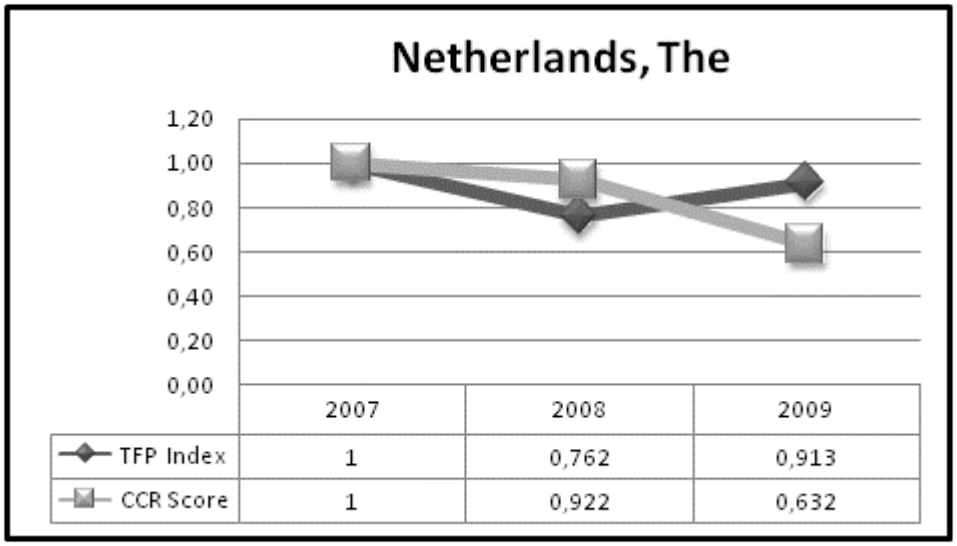


**Figure A.27: TFP and CCR Scores for Netherlands, The**

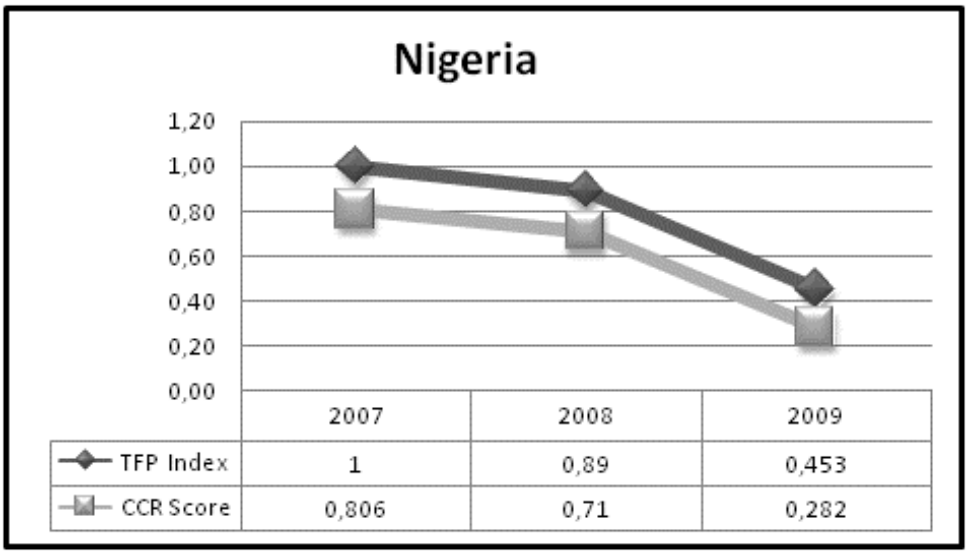


**Figure A.28: TFP and CCR Scores for Nigeria**

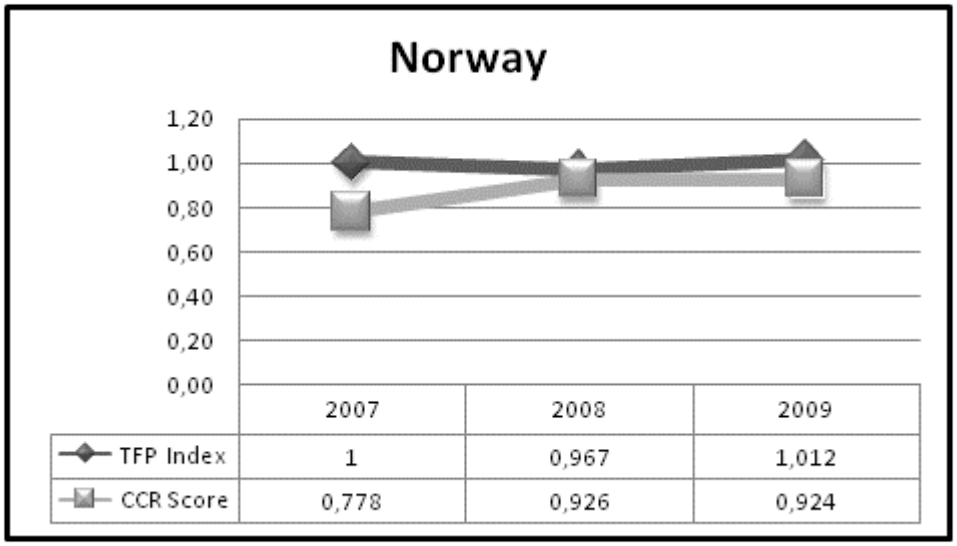


**Figure A.29: TFP and CCR Scores for Norway**

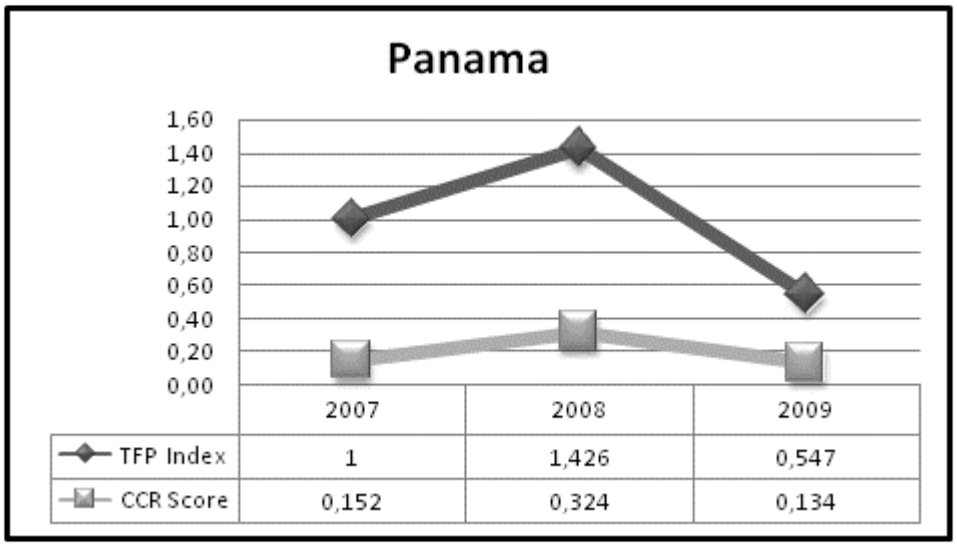


**Figure A.30: TFP and CCR Scores for Panama**

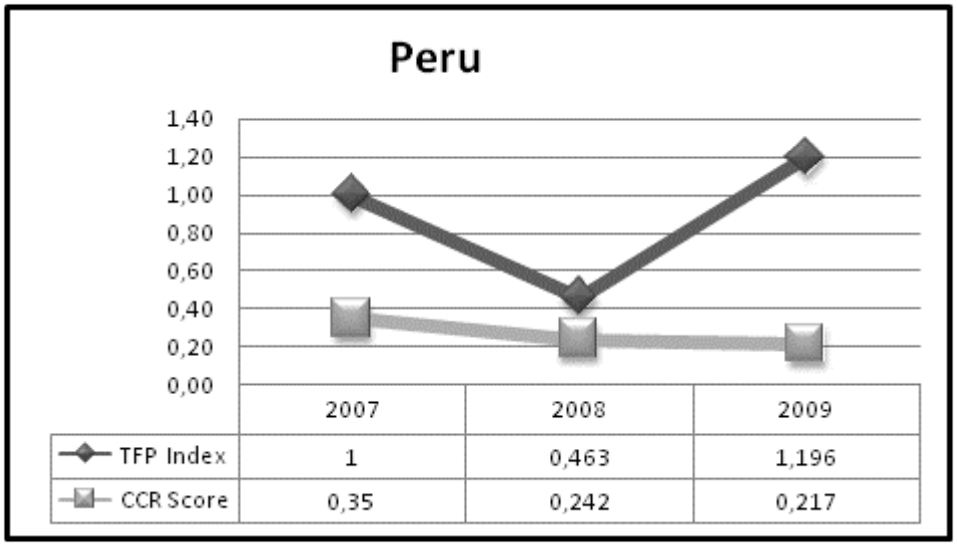


**Figure A.31: TFP and CCR Scores for Peru**

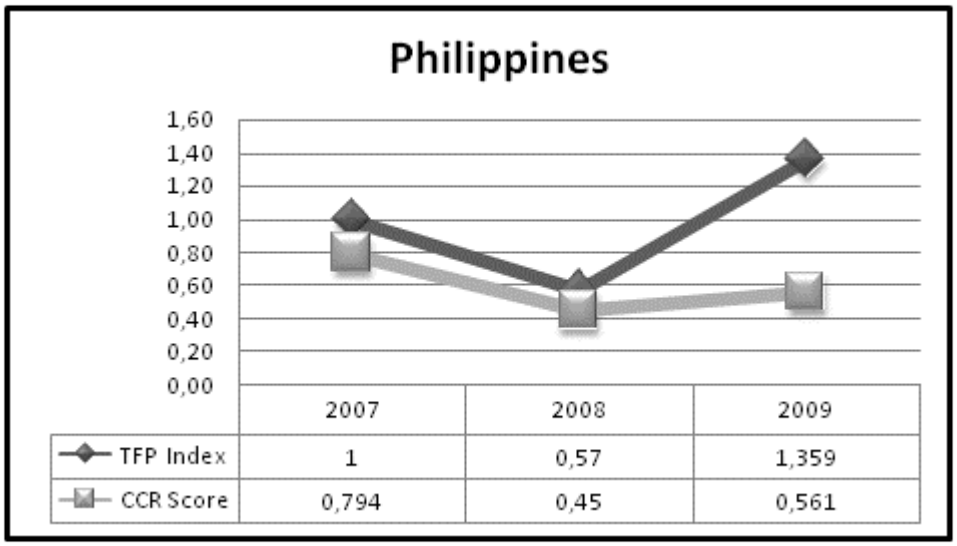


**Figure A.32: TFP and CCR Scores for Philippines**

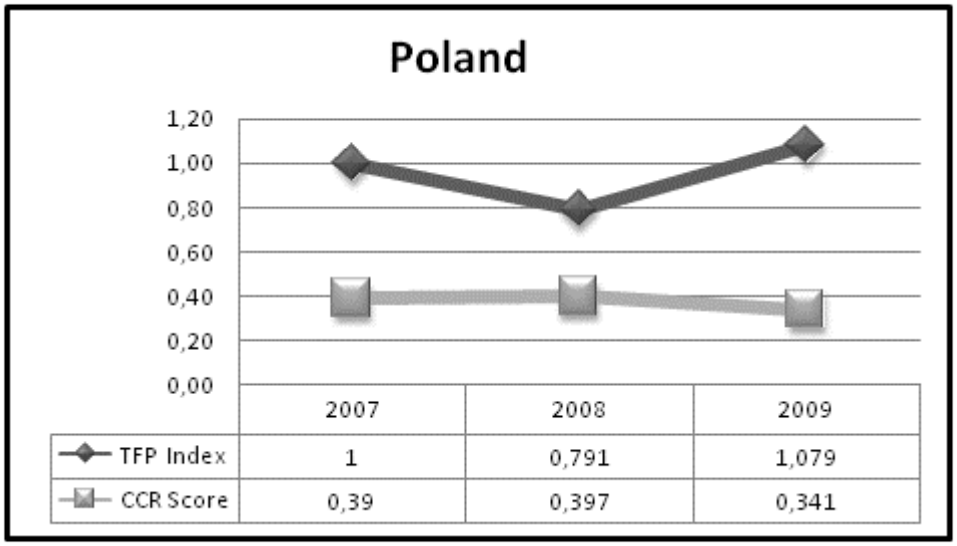


**Figure A.33: TFP and CCR Scores for Poland**

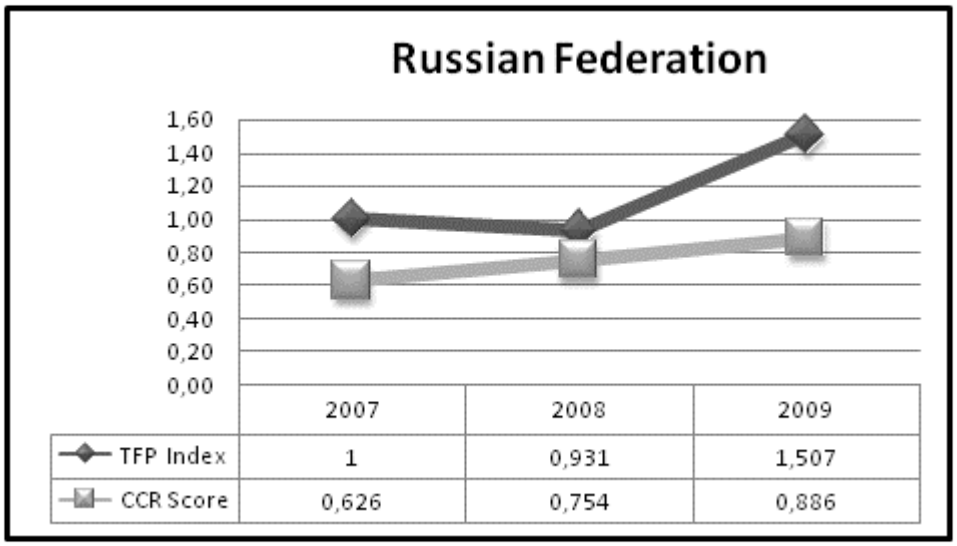


**Figure A.34: TFP and CCR Scores for Russian Federation**

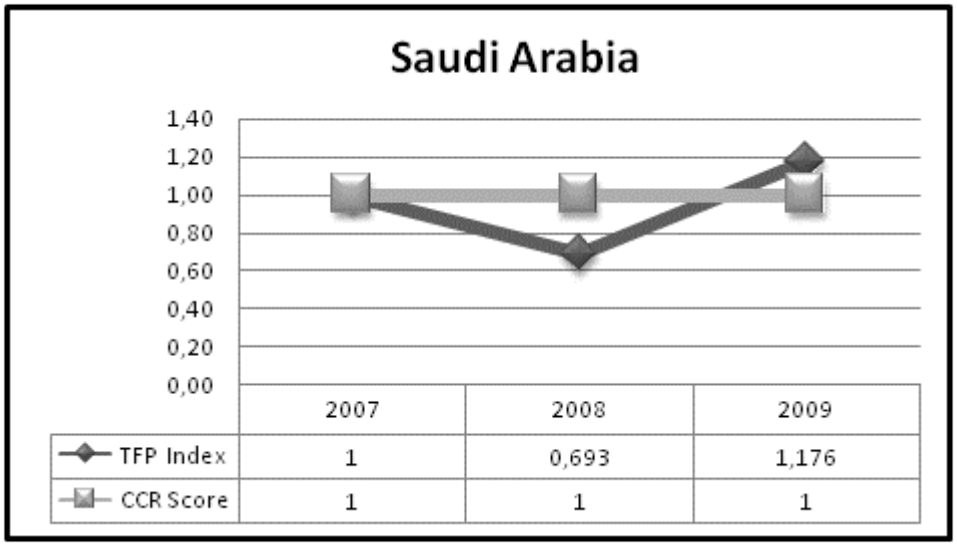


**Figure A.35: TFP and CCR Scores for Saudi Arabia**

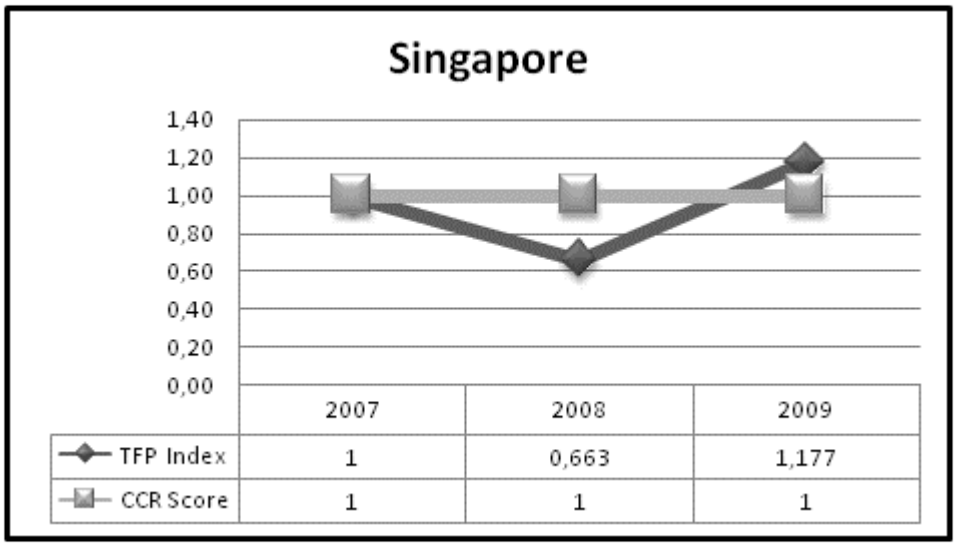


**Figure A.36: TFP and CCR Scores for Singapore**

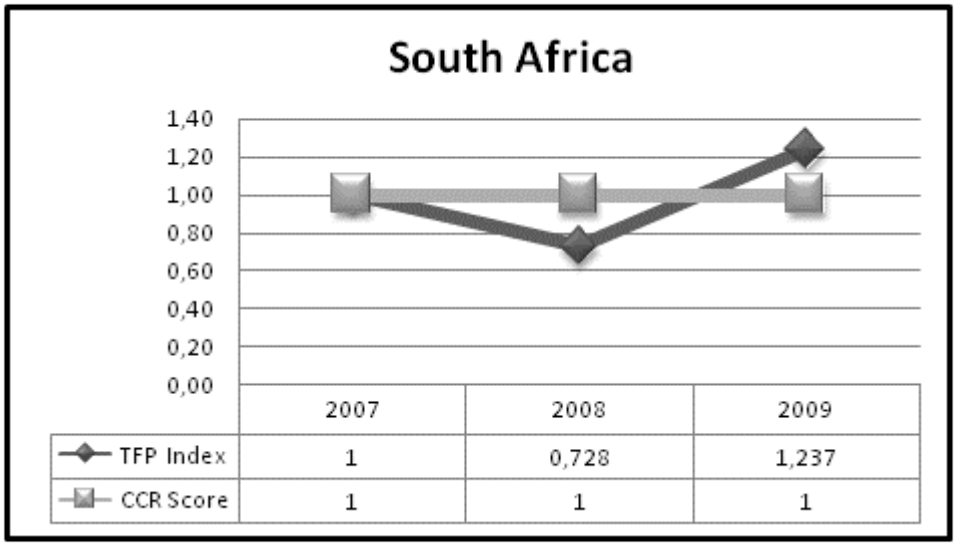


**Figure A.37: TFP and CCR Scores for South Africa**

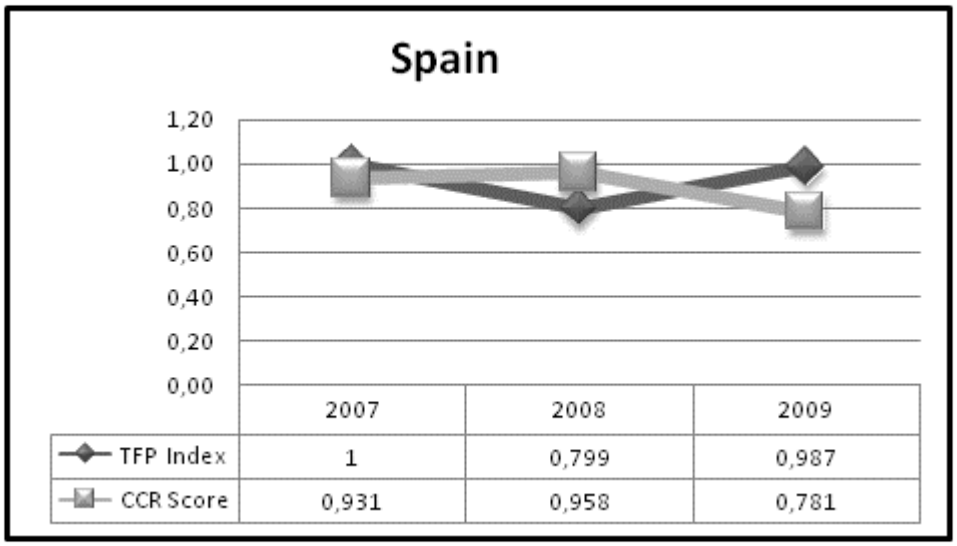


**Figure A.38: TFP and CCR Scores for Spain**

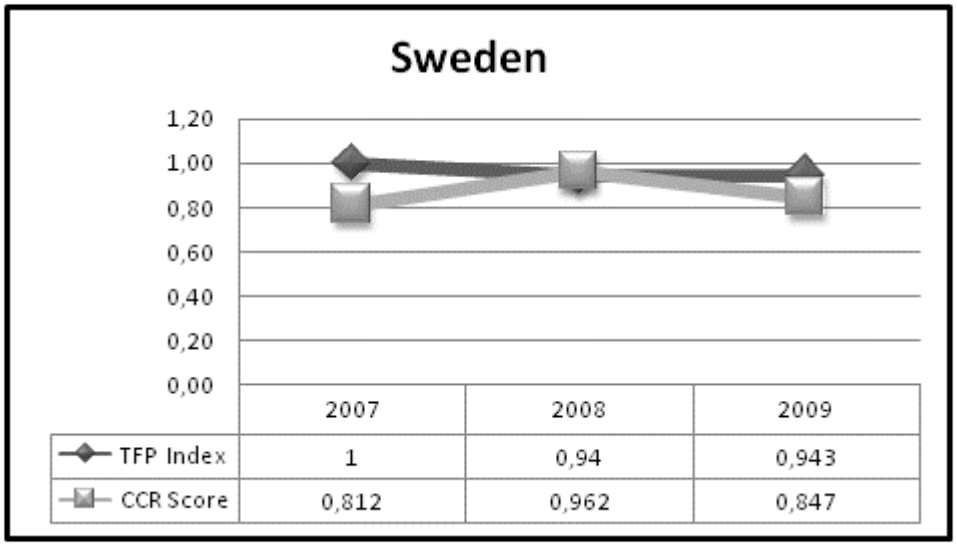


**Figure A.39: TFP and CCR Scores for Sweden**

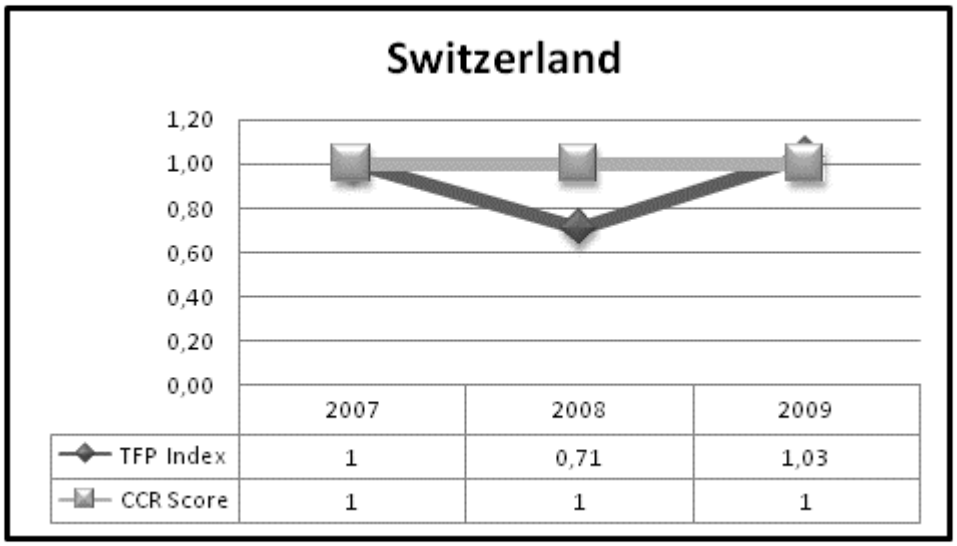


**Figure A.40: TFP and CCR Scores for Switzerland**

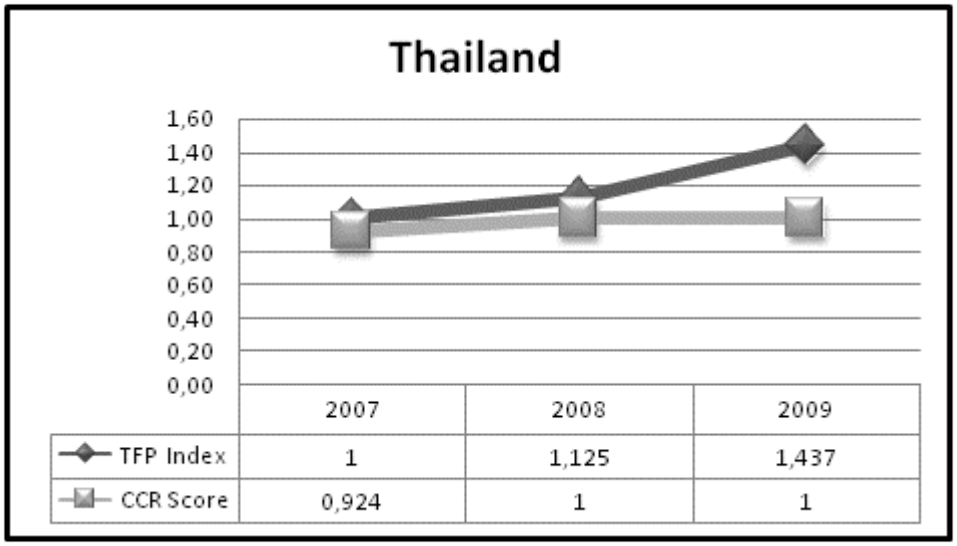


**Figure A.41: TFP and CCR Scores for Thailand**

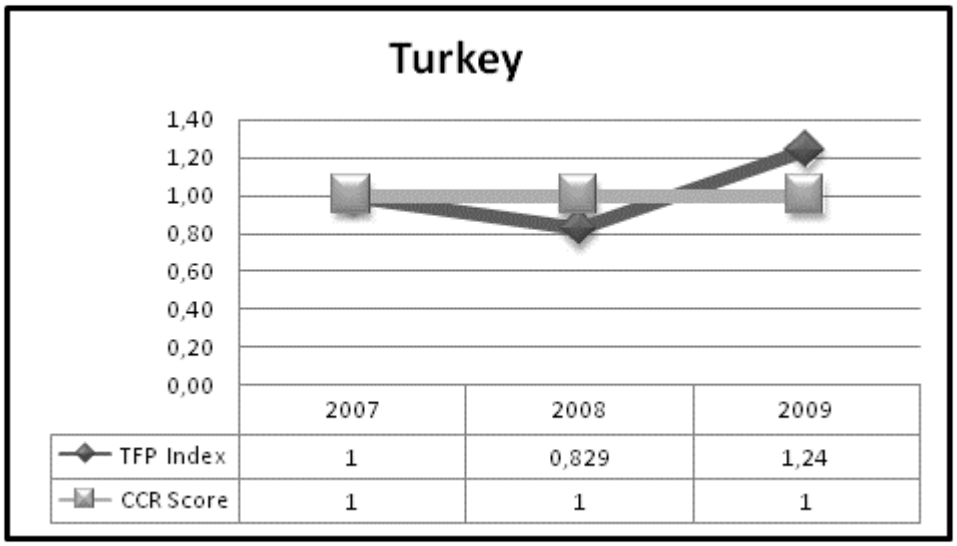


**Figure A.42: TFP and CCR Scores for Turkey**

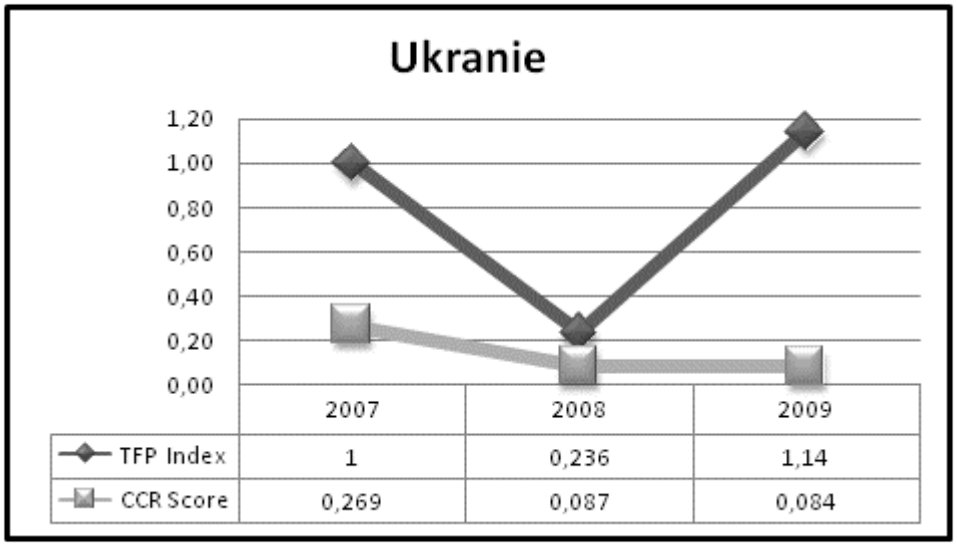


**Figure A.43: TFP and CCR Scores for Ukraine**

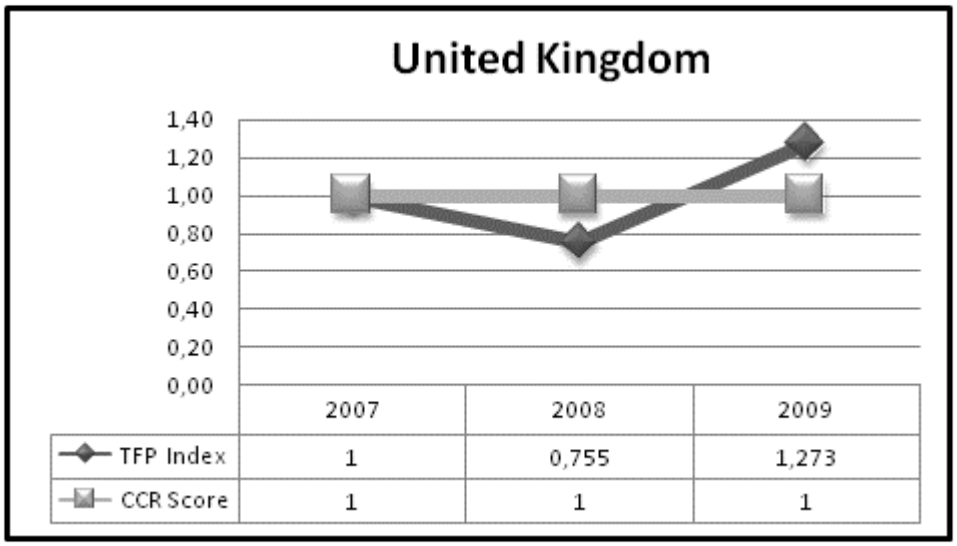


**Figure A.44: TFP and CCR Scores for United Kingdom**

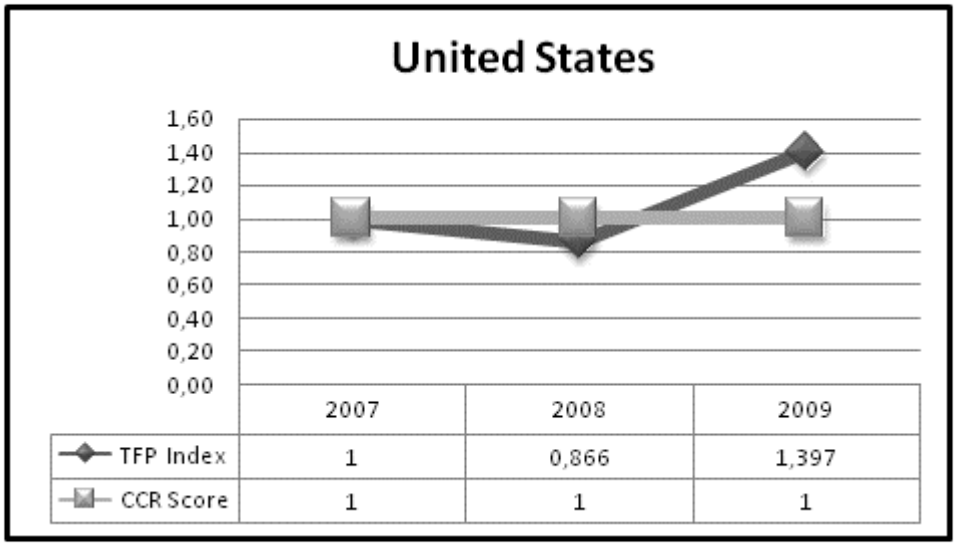


**Figure A.45: TFP and CCR Scores for United States**

## APPENDIX B: Lower and Upper Bounds of Variables

### Table B.1: Lower and Upper Bounds of Variables for α = 0.25

| | Value Traded (Billion USD) | | Market Capitalization (Billion USD) | | Turnover Ratio (%) | | Institutional Environment | | Business Environment | |
|---|---|---|---|---|---|---|---|---|---|---|
| Country | L | U | L | U | L | U | L | U | L | U |
| Argentina | 4.11 | 12.13 | 49.78 | 78.09 | 6.52 | 16.96 | 3.22 | 3.32 | 3.84 | 4.00 |
| Australia | 825.79 | 1,246.54 | 821.33 | 1,288.44 | 84.85 | 108.64 | 5.49 | 5.85 | 5.30 | 5.63 |
| Austria | 45.28 | 117.20 | 58.26 | 189.61 | 44.88 | 66.19 | 5.67 | 5.96 | 5.29 | 5.35 |
| Belgium | 148.79 | 244.72 | 190.94 | 355.13 | 61.02 | 73.40 | 5.55 | 5.78 | 5.02 | 5.43 |
| Brazil | 601.01 | 708.14 | 733.87 | 1,319.62 | 60.63 | 74.18 | 3.62 | 3.68 | 3.67 | 3.95 |
| Canada | 1,341.09 | 1,739.34 | 1,171.91 | 2,060.15 | 86.63 | 115.89 | 5.68 | 6.01 | 5.50 | 5.89 |
| Chile | 36.81 | 42.75 | 151.69 | 212.05 | 21.37 | 22.74 | 4.33 | 5.15 | 4.61 | 4.88 |
| China | 6,050.82 | 8,665.07 | 3,347.12 | 5,921.65 | 136.00 | 217.23 | 3.52 | 4.08 | 4.08 | 4.22 |
| Colombia | 10.87 | 12.83 | 90.76 | 125.46 | 12.09 | 13.18 | 3.36 | 3.73 | 3.89 | 4.28 |
| Czech Republic | 25.94 | 42.76 | 49.81 | 68.24 | 47.62 | 69.97 | 4.16 | 4.28 | 4.31 | 4.75 |
| Egypt | 52.88 | 65.50 | 86.90 | 126.95 | 49.22 | 61.41 | 3.86 | 4.02 | 3.73 | 3.89 |
| Finland | 165.98 | 505.11 | 106.86 | 315.47 | 94.51 | 175.28 | 5.70 | 6.12 | 5.79 | 5.88 |
| France | 1,840.73 | 3,380.54 | 1,612.26 | 2,571.43 | 92.01 | 147.21 | 5.39 | 5.75 | 5.12 | 5.47 |
| Germany | 1,742.98 | 3,298.64 | 1,155.36 | 1,903.53 | 125.29 | 188.58 | 5.69 | 6.01 | 5.44 | 5.58 |
| Hungary | 27.16 | 43.32 | 21.01 | 42.81 | 96.26 | 109.52 | 4.44 | 4.57 | 4.69 | 4.74 |
| India | 1,059.54 | 1,102.89 | 778.92 | 1,659.14 | 84.30 | 110.81 | 3.25 | 3.41 | 3.39 | 3.59 |
| Indonesia | 111.22 | 114.70 | 118.62 | 203.32 | 66.13 | 80.28 | 3.54 | 4.23 | 3.23 | 3.41 |
| Ireland | 23.15 | 111.76 | 34.76 | 120.37 | 56.21 | 87.93 | 5.57 | 5.91 | 5.20 | 5.45 |
| Israel | 93.51 | 112.38 | 146.37 | 222.79 | 55.50 | 58.10 | 4.79 | 5.53 | 4.49 | 4.90 |
| Italy | 512.03 | 1,902.35 | 368.20 | 934.73 | 137.37 | 268.28 | 4.25 | 4.58 | 4.66 | 4.90 |
| Japan | 4,614.33 | 6,342.75 | 3,259.84 | 4,184.58 | 132.00 | 150.32 | 5.46 | 5.80 | 5.14 | 5.38 |
| Kazakhstan | 3.59 | 7.68 | 33.65 | 53.59 | 9.75 | 18.61 | 3.16 | 3.35 | 3.65 | 4.13 |
| Korea | 1,494.87 | 1,875.89 | 580.09 | 1,051.84 | 186.29 | 228.62 | 4.15 | 4.88 | 5.34 | 5.40 |
| Kuwait | 82.63 | 122.23 | 98.75 | 167.83 | 70.70 | 81.42 | 3.89 | 4.03 | 4.51 | 4.83 |
| Malaysia | 76.03 | 133.80 | 204.29 | 308.24 | 33.02 | 48.43 | 4.91 | 5.12 | 4.52 | 4.75 |
| Mexico | 84.84 | 113.76 | 259.58 | 383.44 | 27.92 | 33.50 | 3.53 | 4.13 | 3.83 | 3.90 |
| Netherlands | 738.88 | 1,638.34 | 426.56 | 852.99 | 139.69 | 198.14 | 5.78 | 5.97 | 5.59 | 5.80 |
| Nigeria | 7.62 | 19.16 | 37.44 | 77.21 | 15.30 | 29.03 | 3.65 | 3.80 | 2.86 | 3.05 |
| Norway | 277.88 | 445.98 | 151.25 | 324.87 | 142.18 | 151.08 | 5.88 | 6.09 | 5.63 | 5.90 |
| Panama | 0.07 | 0.22 | 6.31 | 7.68 | 1.05 | 3.50 | 4.34 | 4.74 | 3.99 | 4.13 |
| Peru | 3.63 | 6.72 | 59.16 | 96.91 | 5.33 | 8.18 | 3.68 | 4.09 | 3.85 | 3.94 |
| Philippines | 17.20 | 26.24 | 59.11 | 97.45 | 23.12 | 32.08 | 3.61 | 3.64 | 3.35 | 3.47 |
| Poland | 58.82 | 80.41 | 101.49 | 189.31 | 46.13 | 48.98 | 3.63 | 4.01 | 4.36 | 4.53 |
| Russian Federation | 592.31 | 736.54 | 513.24 | 1,342.61 | 62.93 | 100.13 | 3.03 | 3.14 | 4.11 | 4.38 |
| Saudi Arabia | 383.91 | 641.06 | 264.44 | 466.02 | 123.90 | 155.58 | 4.23 | 4.54 | 4.63 | 4.99 |
| Singapore | 256.93 | 355.90 | 212.71 | 342.81 | 101.70 | 117.20 | 6.10 | 6.28 | 5.84 | 6.02 |
| South Africa | 357.25 | 419.68 | 544.67 | 801.37 | 55.57 | 59.78 | 4.41 | 4.54 | 3.95 | 4.12 |
| Spain | 1,809.51 | 2,831.65 | 1,033.89 | 1,674.38 | 151.33 | 186.67 | 5.00 | 5.50 | 4.82 | 4.91 |
| Sweden | 453.18 | 887.06 | 297.48 | 567.45 | 122.34 | 154.61 | 5.92 | 6.06 | 5.71 | 5.98 |
| Switzerland | 972.98 | 1,709.67 | 914.67 | 1,223.56 | 97.47 | 144.94 | 5.67 | 5.73 | 5.67 | 5.83 |
| Thailand | 110.35 | 130.40 | 111.49 | 181.58 | 67.70 | 103.61 | 4.14 | 4.43 | 4.25 | 4.40 |
| Turkey | 240.67 | 287.68 | 144.88 | 271.36 | 122.57 | 139.97 | 3.40 | 3.74 | 4.37 | 4.56 |
| Ukraine | 0.95 | 2.41 | 18.68 | 89.91 | 2.67 | 3.51 | 2.77 | 3.02 | 3.77 | 3.93 |
| United Kingdom | 4,173.62 | 9,365.12 | 2,088.07 | 3,592.99 | 166.51 | 259.29 | 5.60 | 6.02 | 5.37 | 5.59 |
| United States | 38,003.85 | 45,705.23 | 12,572.53 | 18,729.80 | 220.44 | 319.50 | 5.59 | 5.89 | 5.33 | 5.62 |

*L: Lower Bound Value; U: Upper Bound Value

## Table B.1: Lower and Upper Bounds of Variables for $\alpha = 0.25$ (continued)

| | Financial Stability | | Banking Financial Services | | Non-Banking Binancial Services | | GDP (Billion USD) | | GDP per Capita (USD) | |
|---|---|---|---|---|---|---|---|---|---|---|
| Country | L | U | L | U | L | U | L | U | L | U |
| Argentina | 3.00 | 3.57 | 2.80 | 2.91 | 2.33 | 2.48 | 272.38 | 321.73 | 6,859 | 8,048 |
| Australia | 5.15 | 5.41 | 4.34 | 5.05 | 4.04 | 4.34 | 873.82 | 1,010.78 | 41,065 | 46,944 |
| Austria | 4.80 | 5.56 | 4.22 | 4.30 | 1.89 | 2.08 | 374.49 | 406.27 | 45,028 | 48,695 |
| Belgium | 4.70 | 5.12 | 4.48 | 4.86 | 2.31 | 2.53 | 461.76 | 496.82 | 43,289 | 46,313 |
| Brazil | 3.98 | 5.15 | 2.66 | 3.40 | 2.92 | 3.47 | 1,417.84 | 1,621.79 | 7,419 | 8,429 |
| Canada | 5.09 | 5.49 | 4.78 | 5.07 | 4.09 | 4.46 | 1,358.07 | 1,480.35 | 40,496 | 44,548 |
| Chile | 4.70 | 5.56 | 3.29 | 3.65 | 1.73 | 1.87 | 163.83 | 169.22 | 9,703 | 10,095 |
| China | 4.86 | 5.11 | 4.81 | 4.96 | 3.30 | 4.17 | 3,751.00 | 4,869.55 | 2,842 | 3,662 |
| Colombia | 4.31 | 4.71 | 2.59 | 3.16 | 1.71 | 2.02 | 214.03 | 240.45 | 4,787 | 5,323 |
| Czech Republic | 4.42 | 5.01 | 3.15 | 3.87 | 1.43 | 1.67 | 178.23 | 209.63 | 17,178 | 20,081 |
| Egypt | 3.63 | 4.36 | 3.05 | 3.32 | 1.85 | 2.16 | 138.56 | 182.02 | 1,722 | 2,202 |
| Finland | 5.13 | 5.26 | 3.26 | 4.01 | 2.13 | 2.23 | 239.98 | 264.35 | 45,062 | 49,805 |
| France | 5.14 | 5.25 | 4.06 | 4.44 | 3.54 | 4.96 | 2,607.86 | 2,803.02 | 40,746 | 43,616 |
| Germany | 4.88 | 5.66 | 4.26 | 4.72 | 3.45 | 3.97 | 3,329.37 | 3,558.41 | 40,518 | 43,365 |
| Hungary | 3.04 | 3.65 | 2.25 | 3.19 | 1.49 | 1.89 | 131.41 | 150.69 | 13,100 | 15,006 |
| India | 4.08 | 4.56 | 2.72 | 3.11 | 3.15 | 3.46 | 1,218.86 | 1,290.83 | 1,073 | 1,125 |
| Indonesia | 3.84 | 4.43 | 2.62 | 4.11 | 1.68 | 2.04 | 451.70 | 532.83 | 2,004 | 2,323 |
| Ireland | 3.82 | 5.21 | 4.85 | 5.05 | 3.16 | 3.20 | 235.32 | 264.67 | 53,189 | 60,036 |
| Israel | 4.47 | 4.69 | 3.88 | 4.11 | 1.97 | 2.23 | 174.09 | 200.42 | 24,007 | 27,303 |
| Italy | 4.33 | 4.73 | 4.04 | 4.34 | 2.73 | 3.22 | 2,113.64 | 2,251.52 | 35,223 | 37,699 |
| Japan | 4.49 | 5.43 | 4.98 | 5.17 | 4.06 | 4.41 | 4,505.20 | 5,023.49 | 35,265 | 39,371 |
| Kazakhstan | 3.52 | 3.76 | 2.61 | 3.02 | 2.62 | 3.37 | 107.47 | 128.91 | 6,893 | 8,200 |
| Korea | 4.22 | 4.65 | 4.01 | 4.65 | 3.17 | 4.02 | 857.23 | 1,019.78 | 17,599 | 21,031 |
| Kuwait | 5.04 | 5.48 | 3.75 | 3.92 | 1.09 | 1.36 | 102.50 | 139.70 | 37,183 | 51,467 |
| Malaysia | 5.15 | 5.56 | 4.67 | 5.47 | 2.06 | 2.99 | 188.25 | 214.64 | 7,029 | 7,916 |
| Mexico | 4.76 | 5.09 | 2.43 | 2.64 | 1.91 | 2.00 | 912.50 | 1,073.81 | 8,543 | 10,121 |
| Netherlands | 4.61 | 5.53 | 4.41 | 5.23 | 3.71 | 4.04 | 781.77 | 852.68 | 47,613 | 51,786 |
| Nigeria | 3.31 | 4.54 | 2.44 | 2.71 | 1.25 | 1.43 | 167.69 | 198.59 | 1,119 | 1,308 |
| Norway | 5.46 | 5.84 | 4.23 | 4.34 | 2.16 | 2.35 | 383.21 | 435.07 | 79,890 | 91,499 |
| Panama | 3.28 | 4.45 | 3.84 | 4.05 | 1.61 | 1.88 | 20.64 | 24.33 | 6,146 | 7,071 |
| Peru | 4.03 | 4.88 | 2.57 | 2.76 | 1.61 | 1.97 | 112.90 | 130.02 | 3,945 | 4,475 |
| Philippines | 3.52 | 4.32 | 2.66 | 2.91 | 1.79 | 2.08 | 148.35 | 165.25 | 1,656 | 1,821 |
| Poland | 4.21 | 4.72 | 3.14 | 3.20 | 1.72 | 2.21 | 426.51 | 503.76 | 11,186 | 13,211 |
| Russian Federation | 4.23 | 4.48 | 1.86 | 2.67 | 3.82 | 4.24 | 1,248.85 | 1,575.14 | 8,800 | 11,094 |
| Saudi Arabia | 5.69 | 6.08 | 3.54 | 3.95 | 1.40 | 1.87 | 372.90 | 452.34 | 14,867 | 18,325 |
| Singapore | 5.62 | 6.08 | 3.88 | 4.67 | 3.03 | 3.55 | 178.13 | 190.56 | 37,033 | 39,593 |
| South Africa | 4.59 | 4.71 | 3.70 | 4.01 | 2.20 | 2.68 | 278.68 | 286.07 | 5,696 | 5,896 |
| Spain | 4.12 | 4.92 | 4.90 | 5.20 | 3.35 | 3.74 | 1,445.69 | 1,560.92 | 31,857 | 34,277 |
| Sweden | 4.73 | 5.21 | 3.91 | 4.76 | 2.47 | 2.82 | 420.18 | 481.31 | 45,380 | 52,303 |
| Switzerland | 5.65 | 6.05 | 3.98 | 4.55 | 2.81 | 3.14 | 448.57 | 499.82 | 59,025 | 65,182 |
| Thailand | 4.55 | 4.68 | 3.51 | 4.23 | 1.59 | 1.82 | 251.28 | 270.26 | 3,740 | 4,005 |
| Turkey | 3.00 | 3.77 | 2.99 | 3.26 | 1.85 | 2.12 | 622.74 | 709.54 | 8,377 | 9,627 |
| Ukraine | 2.94 | 3.18 | 2.44 | 3.00 | 2.09 | 2.46 | 120.84 | 170.95 | 2,618 | 3,691 |
| United Kingdom | 4.14 | 4.87 | 5.33 | 5.47 | 5.72 | 6.50 | 2,296.56 | 2,764.94 | 37,214 | 45,266 |
| United States | 4.34 | 5.27 | 4.06 | 5.40 | 5.96 | 6.07 | 14,076.10 | 14,306.58 | 46,149 | 47,063 |

*L: Lower Bound Value; U: Upper Bound Value

## Table B.2: Lower and Upper Bounds of Variables for $\alpha = 0.50$

| | Value Traded (Billion USD) | | Market Capitalization (Billion USD) | | Turnover Ratio (%) | | Institutional Environment | | Business Environment | |
|---|---|---|---|---|---|---|---|---|---|---|
| Country | L | U | L | U | L | U | L | U | L | U |
| Argentina | 5.49 | 10.84 | 50.62 | 69.50 | 7.65 | 14.60 | 3.22 | 3.29 | 3.87 | 3.97 |
| Australia | 889.77 | 1,170.27 | 967.04 | 1,278.45 | 90.92 | 106.78 | 5.52 | 5.75 | 5.36 | 5.58 |
| Austria | 65.03 | 112.97 | 62.94 | 150.50 | 49.19 | 63.39 | 5.69 | 5.88 | 5.29 | 5.33 |
| Belgium | 169.79 | 233.74 | 214.44 | 323.90 | 62.45 | 70.70 | 5.57 | 5.72 | 5.04 | 5.31 |
| Brazil | 617.07 | 688.49 | 878.36 | 1,268.86 | 65.05 | 74.09 | 3.63 | 3.67 | 3.72 | 3.90 |
| Canada | 1,442.55 | 1,708.05 | 1,341.59 | 1,933.76 | 88.55 | 108.06 | 5.75 | 5.97 | 5.58 | 5.83 |
| Chile | 37.06 | 41.02 | 170.95 | 211.19 | 21.57 | 22.49 | 4.38 | 4.92 | 4.69 | 4.87 |
| China | 6,631.12 | 8,373.95 | 3,900.63 | 5,616.98 | 150.70 | 204.85 | 3.70 | 4.08 | 4.08 | 4.18 |
| Colombia | 11.41 | 12.72 | 94.49 | 117.63 | 12.43 | 13.16 | 3.41 | 3.66 | 3.97 | 4.22 |
| Czech Republic | 31.27 | 42.48 | 50.77 | 63.05 | 54.64 | 69.55 | 4.17 | 4.26 | 4.43 | 4.72 |
| Egypt | 52.95 | 61.36 | 87.92 | 114.62 | 52.84 | 60.96 | 3.86 | 3.97 | 3.76 | 3.86 |
| Finland | 240.79 | 466.88 | 122.69 | 261.77 | 114.71 | 168.56 | 5.73 | 6.01 | 5.82 | 5.88 |
| France | 2,315.65 | 3,342.19 | 1,732.19 | 2,371.63 | 105.17 | 141.97 | 5.43 | 5.67 | 5.15 | 5.38 |
| Germany | 2,197.08 | 3,234.19 | 1,202.77 | 1,701.54 | 143.43 | 185.62 | 5.72 | 5.93 | 5.46 | 5.56 |
| Hungary | 28.37 | 39.15 | 23.43 | 37.97 | 99.51 | 108.35 | 4.47 | 4.56 | 4.70 | 4.73 |
| India | 1,069.32 | 1,098.22 | 912.36 | 1,499.17 | 84.59 | 102.27 | 3.30 | 3.40 | 3.43 | 3.56 |
| Indonesia | 111.76 | 114.08 | 138.48 | 194.94 | 67.85 | 77.29 | 3.54 | 4.00 | 3.24 | 3.36 |
| Ireland | 27.84 | 86.91 | 39.64 | 96.71 | 65.82 | 86.97 | 5.58 | 5.81 | 5.26 | 5.42 |
| Israel | 98.72 | 111.31 | 158.28 | 209.23 | 55.59 | 57.33 | 4.91 | 5.40 | 4.53 | 4.80 |
| Italy | 564.34 | 1,491.21 | 419.09 | 796.77 | 165.05 | 252.32 | 4.27 | 4.49 | 4.70 | 4.85 |
| Japan | 5,036.03 | 6,188.32 | 3,299.19 | 3,915.68 | 135.20 | 147.41 | 5.49 | 5.71 | 5.15 | 5.31 |
| Kazakhstan | 3.74 | 6.47 | 36.23 | 49.52 | 10.41 | 16.31 | 3.19 | 3.31 | 3.78 | 4.11 |
| Korea | 1,523.75 | 1,777.76 | 665.55 | 980.05 | 191.39 | 219.61 | 4.19 | 4.67 | 5.34 | 5.39 |
| Kuwait | 95.32 | 121.72 | 101.55 | 147.61 | 72.53 | 79.68 | 3.91 | 4.00 | 4.51 | 4.72 |
| Malaysia | 79.09 | 117.61 | 221.51 | 290.81 | 33.09 | 43.37 | 4.96 | 5.10 | 4.54 | 4.70 |
| Mexico | 92.63 | 111.91 | 286.57 | 369.15 | 28.94 | 32.67 | 3.55 | 3.95 | 3.86 | 3.90 |
| Netherlands | 873.60 | 1,473.24 | 465.22 | 749.50 | 149.52 | 188.49 | 5.79 | 5.92 | 5.62 | 5.75 |
| Nigeria | 10.67 | 18.36 | 41.56 | 68.07 | 19.60 | 28.75 | 3.67 | 3.77 | 2.89 | 3.02 |
| Norway | 308.01 | 420.07 | 176.58 | 292.33 | 144.06 | 149.98 | 5.89 | 6.02 | 5.65 | 5.83 |
| Panama | 0.09 | 0.19 | 6.39 | 7.31 | 1.37 | 3.00 | 4.40 | 4.67 | 4.02 | 4.12 |
| Peru | 4.12 | 6.19 | 62.69 | 87.86 | 5.66 | 7.56 | 3.69 | 3.96 | 3.86 | 3.92 |
| Philippines | 17.20 | 23.23 | 66.12 | 91.68 | 24.09 | 30.05 | 3.61 | 3.63 | 3.35 | 3.43 |
| Poland | 61.87 | 76.26 | 112.75 | 171.30 | 46.59 | 48.48 | 3.72 | 3.97 | 4.38 | 4.49 |
| Russian Federation | 622.39 | 718.54 | 629.30 | 1,182.22 | 66.96 | 91.76 | 3.06 | 3.13 | 4.15 | 4.32 |
| Saudi Arabia | 430.85 | 602.28 | 282.55 | 416.94 | 128.54 | 149.66 | 4.27 | 4.48 | 4.71 | 4.95 |
| Singapore | 261.59 | 327.57 | 245.39 | 332.13 | 102.07 | 112.40 | 6.13 | 6.24 | 5.87 | 5.98 |
| South Africa | 372.00 | 413.62 | 598.05 | 769.19 | 56.13 | 58.94 | 4.42 | 4.50 | 3.98 | 4.09 |
| Spain | 2,019.75 | 2,701.18 | 1,121.67 | 1,548.67 | 160.08 | 183.64 | 5.04 | 5.37 | 4.84 | 4.90 |
| Sweden | 516.04 | 805.29 | 342.42 | 522.40 | 130.70 | 152.21 | 5.96 | 6.06 | 5.78 | 5.96 |
| Switzerland | 1,150.41 | 1,641.54 | 966.68 | 1,172.61 | 112.65 | 144.30 | 5.68 | 5.72 | 5.72 | 5.82 |
| Thailand | 112.49 | 125.85 | 120.39 | 167.12 | 71.20 | 95.14 | 4.20 | 4.39 | 4.27 | 4.36 |
| Turkey | 241.62 | 272.96 | 171.83 | 256.15 | 126.61 | 138.21 | 3.43 | 3.66 | 4.38 | 4.50 |
| Ukraine | 1.30 | 2.28 | 20.57 | 68.06 | 2.74 | 3.30 | 2.79 | 2.96 | 3.81 | 3.91 |
| United Kingdom | 4,944.73 | 8,405.73 | 2,324.20 | 3,327.48 | 186.63 | 248.48 | 5.67 | 5.94 | 5.40 | 5.54 |
| United States | 39,540.30 | 44,674.55 | 13,407.45 | 17,512.30 | 224.38 | 290.42 | 5.61 | 5.81 | 5.35 | 5.54 |

*L: Lower Bound Value; U: Upper Bound Value

## Table B.2: Lower and Upper Bounds of Variables for $\alpha = 0.50$ (continued)

| | Financial Stability | | Banking Financial Services | | Non-Banking Binancial Services | | GDP (Billion USD) | | GDP per Capita (USD) | |
|---|---|---|---|---|---|---|---|---|---|---|
| Country | L | U | L | U | L | U | L | U | L | U |
| Argentina | 3.08 | 3.46 | 2.82 | 2.89 | 2.38 | 2.48 | 283.97 | 316.87 | 7,115 | 7,907 |
| Australia | 5.17 | 5.35 | 4.57 | 5.04 | 4.11 | 4.31 | 890.83 | 982.13 | 41,470 | 45,389 |
| Austria | 4.81 | 5.31 | 4.23 | 4.28 | 1.92 | 2.04 | 376.69 | 397.88 | 45,206 | 47,650 |
| Belgium | 4.75 | 5.03 | 4.58 | 4.84 | 2.37 | 2.52 | 464.89 | 488.27 | 43,416 | 45,433 |
| Brazil | 4.37 | 5.14 | 2.85 | 3.34 | 3.01 | 3.38 | 1,469.70 | 1,605.67 | 7,653 | 8,327 |
| Canada | 5.15 | 5.42 | 4.80 | 4.99 | 4.18 | 4.43 | 1,380.07 | 1,461.59 | 41,392 | 44,094 |
| Chile | 4.93 | 5.50 | 3.34 | 3.58 | 1.77 | 1.87 | 163.99 | 167.58 | 9,761 | 10,022 |
| China | 4.88 | 5.05 | 4.84 | 4.94 | 3.31 | 3.88 | 4,007.95 | 4,753.65 | 3,032 | 3,579 |
| Colombia | 4.36 | 4.62 | 2.61 | 2.99 | 1.77 | 1.98 | 220.70 | 238.31 | 4,900 | 5,258 |
| Czech Republic | 4.54 | 4.94 | 3.39 | 3.87 | 1.44 | 1.60 | 182.24 | 203.18 | 17,498 | 19,434 |
| Egypt | 3.84 | 4.33 | 3.06 | 3.25 | 1.95 | 2.15 | 146.65 | 175.62 | 1,814 | 2,134 |
| Finland | 5.17 | 5.26 | 3.43 | 3.93 | 2.14 | 2.21 | 241.97 | 258.22 | 45,543 | 48,705 |
| France | 5.15 | 5.22 | 4.07 | 4.32 | 3.69 | 4.64 | 2,621.70 | 2,751.81 | 40,848 | 42,761 |
| Germany | 5.03 | 5.56 | 4.28 | 4.59 | 3.48 | 3.82 | 3,329.59 | 3,482.28 | 40,569 | 42,467 |
| Hungary | 3.20 | 3.60 | 2.29 | 2.92 | 1.50 | 1.77 | 133.86 | 146.71 | 13,333 | 14,603 |
| India | 4.13 | 4.45 | 2.84 | 3.09 | 3.18 | 3.39 | 1,223.52 | 1,271.50 | 1,081 | 1,115 |
| Indonesia | 4.02 | 4.42 | 2.62 | 3.62 | 1.77 | 2.02 | 471.30 | 525.39 | 2,084 | 2,297 |
| Ireland | 4.04 | 4.97 | 4.89 | 5.03 | 3.17 | 3.20 | 243.45 | 263.02 | 55,328 | 59,893 |
| Israel | 4.48 | 4.62 | 3.91 | 4.06 | 2.05 | 2.22 | 181.19 | 198.75 | 24,757 | 26,954 |
| Italy | 4.37 | 4.63 | 4.07 | 4.27 | 2.76 | 3.09 | 2,114.49 | 2,206.42 | 35,362 | 37,013 |
| Japan | 4.52 | 5.14 | 5.04 | 5.16 | 4.09 | 4.32 | 4,632.46 | 4,977.99 | 36,266 | 39,003 |
| Kazakhstan | 3.54 | 3.70 | 2.69 | 2.97 | 2.68 | 3.19 | 110.08 | 124.37 | 7,015 | 7,885 |
| Korea | 4.29 | 4.58 | 4.06 | 4.49 | 3.32 | 3.89 | 881.96 | 990.32 | 18,120 | 20,408 |
| Kuwait | 5.18 | 5.47 | 3.76 | 3.88 | 1.10 | 1.29 | 106.58 | 131.38 | 39,151 | 48,674 |
| Malaysia | 5.16 | 5.43 | 4.68 | 5.21 | 2.19 | 2.81 | 189.87 | 207.46 | 7,029 | 7,621 |
| Mexico | 4.84 | 5.06 | 2.48 | 2.62 | 1.93 | 2.00 | 950.20 | 1,057.73 | 8,942 | 9,995 |
| Netherlands | 4.71 | 5.33 | 4.58 | 5.12 | 3.76 | 3.99 | 785.22 | 832.50 | 47,714 | 50,496 |
| Nigeria | 3.55 | 4.37 | 2.44 | 2.63 | 1.26 | 1.37 | 169.46 | 190.06 | 1,121 | 1,246 |
| Norway | 5.55 | 5.80 | 4.27 | 4.34 | 2.20 | 2.32 | 384.65 | 419.23 | 80,692 | 88,431 |
| Panama | 3.55 | 4.33 | 3.90 | 4.04 | 1.62 | 1.80 | 21.49 | 23.95 | 6,371 | 6,988 |
| Peru | 4.30 | 4.86 | 2.62 | 2.75 | 1.62 | 1.86 | 118.30 | 129.72 | 4,120 | 4,473 |
| Philippines | 3.72 | 4.25 | 2.69 | 2.86 | 1.80 | 1.99 | 152.63 | 163.90 | 1,688 | 1,798 |
| Poland | 4.32 | 4.67 | 3.15 | 3.19 | 1.73 | 2.05 | 427.70 | 479.20 | 11,215 | 12,565 |
| Russian Federation | 4.29 | 4.46 | 1.93 | 2.46 | 3.92 | 4.21 | 1,265.80 | 1,483.33 | 8,915 | 10,445 |
| Saudi Arabia | 5.79 | 6.04 | 3.56 | 3.83 | 1.40 | 1.72 | 376.63 | 429.58 | 15,193 | 17,499 |
| Singapore | 5.64 | 5.94 | 4.14 | 4.66 | 3.14 | 3.49 | 179.50 | 187.78 | 37,530 | 39,236 |
| South Africa | 4.62 | 4.70 | 3.72 | 3.92 | 2.28 | 2.59 | 280.91 | 285.83 | 5,726 | 5,859 |
| Spain | 4.30 | 4.83 | 4.96 | 5.16 | 3.45 | 3.71 | 1,450.55 | 1,527.36 | 31,939 | 33,553 |
| Sweden | 4.85 | 5.17 | 4.14 | 4.71 | 2.54 | 2.77 | 434.29 | 475.04 | 47,106 | 51,721 |
| Switzerland | 5.65 | 5.92 | 4.16 | 4.54 | 2.87 | 3.09 | 463.02 | 497.19 | 60,560 | 64,664 |
| Thailand | 4.56 | 4.64 | 3.52 | 4.00 | 1.59 | 1.75 | 255.44 | 268.10 | 3,791 | 3,968 |
| Turkey | 3.23 | 3.75 | 3.02 | 3.20 | 1.87 | 2.05 | 630.88 | 688.75 | 8,540 | 9,373 |
| Ukraine | 3.01 | 3.16 | 2.50 | 2.88 | 2.19 | 2.44 | 128.13 | 161.54 | 2,768 | 3,484 |
| United Kingdom | 4.28 | 4.77 | 5.34 | 5.44 | 5.94 | 6.46 | 2,418.59 | 2,730.85 | 39,263 | 44,631 |
| United States | 4.41 | 5.04 | 4.11 | 5.01 | 5.99 | 6.06 | 14,090.40 | 14,244.05 | 46,308 | 46,918 |

*L: Lower Bound Value; U: Upper Bound Value

## Table B.3: Lower and Upper Bounds of Variables for $\alpha = 0.75$

| | Value Traded (Billion USD) | | Market Capitalization (Billion USD) | | Turnover Ratio (%) | | Institutional Environment | | Business Environment | |
|---|---|---|---|---|---|---|---|---|---|---|
| Country | L | U | L | U | L | U | L | U | L | U |
| Argentina | 6.87 | 9.54 | 51.47 | 60.90 | 8.77 | 12.25 | 3.23 | 3.26 | 3.89 | 3.95 |
| Australia | 953.74 | 1,093.99 | 1,112.75 | 1,268.45 | 96.99 | 104.92 | 5.54 | 5.66 | 5.42 | 5.53 |
| Austria | 84.77 | 108.75 | 67.62 | 111.40 | 53.49 | 60.60 | 5.70 | 5.79 | 5.29 | 5.31 |
| Belgium | 190.78 | 222.76 | 237.93 | 292.66 | 63.87 | 68.00 | 5.58 | 5.65 | 5.06 | 5.20 |
| Brazil | 633.13 | 668.84 | 1,022.84 | 1,218.09 | 69.48 | 74.00 | 3.63 | 3.65 | 3.76 | 3.85 |
| Canada | 1,544.01 | 1,676.76 | 1,511.28 | 1,807.36 | 90.48 | 100.23 | 5.81 | 5.92 | 5.65 | 5.78 |
| Chile | 37.31 | 39.29 | 190.21 | 210.33 | 21.77 | 22.23 | 4.42 | 4.69 | 4.76 | 4.85 |
| China | 7,211.41 | 8,082.82 | 4,454.14 | 5,312.32 | 165.40 | 192.48 | 3.89 | 4.07 | 4.09 | 4.13 |
| Colombia | 11.95 | 12.60 | 98.23 | 109.79 | 12.76 | 13.13 | 3.47 | 3.59 | 4.04 | 4.17 |
| Czech Republic | 36.60 | 42.21 | 51.73 | 57.87 | 61.67 | 69.12 | 4.19 | 4.23 | 4.55 | 4.70 |
| Egypt | 53.01 | 57.22 | 88.94 | 102.29 | 56.45 | 60.52 | 3.87 | 3.92 | 3.78 | 3.84 |
| Finland | 315.60 | 428.64 | 138.53 | 208.07 | 134.91 | 161.84 | 5.75 | 5.89 | 5.84 | 5.87 |
| France | 2,790.57 | 3,303.84 | 1,852.11 | 2,171.84 | 118.34 | 136.74 | 5.47 | 5.59 | 5.17 | 5.29 |
| Germany | 2,651.19 | 3,169.74 | 1,250.17 | 1,499.56 | 161.56 | 182.66 | 5.75 | 5.86 | 5.49 | 5.53 |
| Hungary | 29.59 | 34.98 | 25.86 | 33.13 | 102.75 | 107.17 | 4.49 | 4.54 | 4.70 | 4.72 |
| India | 1,079.11 | 1,093.56 | 1,045.80 | 1,339.21 | 84.89 | 93.73 | 3.34 | 3.39 | 3.47 | 3.54 |
| Indonesia | 112.31 | 113.47 | 158.33 | 186.57 | 69.58 | 74.29 | 3.54 | 3.77 | 3.25 | 3.31 |
| Ireland | 32.52 | 62.06 | 44.52 | 73.06 | 75.43 | 86.00 | 5.60 | 5.71 | 5.31 | 5.39 |
| Israel | 103.94 | 110.23 | 170.19 | 195.66 | 55.69 | 56.55 | 5.02 | 5.26 | 4.56 | 4.70 |
| Italy | 616.64 | 1,080.08 | 469.97 | 658.81 | 192.72 | 236.36 | 4.30 | 4.41 | 4.73 | 4.81 |
| Japan | 5,457.74 | 6,033.88 | 3,338.54 | 3,646.79 | 138.40 | 144.51 | 5.51 | 5.63 | 5.16 | 5.24 |
| Kazakhstan | 3.89 | 5.25 | 38.80 | 45.45 | 11.07 | 14.02 | 3.21 | 3.27 | 3.92 | 4.08 |
| Korea | 1,552.62 | 1,679.62 | 751.00 | 908.25 | 196.50 | 210.61 | 4.22 | 4.47 | 5.35 | 5.37 |
| Kuwait | 108.01 | 121.21 | 104.36 | 127.39 | 74.37 | 77.94 | 3.92 | 3.97 | 4.51 | 4.62 |
| Malaysia | 82.15 | 101.41 | 238.73 | 273.38 | 33.17 | 38.30 | 5.00 | 5.07 | 4.57 | 4.64 |
| Mexico | 100.42 | 110.06 | 313.57 | 354.86 | 29.97 | 31.83 | 3.57 | 3.77 | 3.88 | 3.90 |
| Netherlands | 1,008.32 | 1,308.14 | 503.88 | 646.02 | 159.35 | 178.83 | 5.81 | 5.87 | 5.64 | 5.71 |
| Nigeria | 13.72 | 17.57 | 45.68 | 58.94 | 23.90 | 28.48 | 3.69 | 3.74 | 2.92 | 2.98 |
| Norway | 338.13 | 394.16 | 201.90 | 259.78 | 145.93 | 148.89 | 5.89 | 5.96 | 5.66 | 5.75 |
| Panama | 0.10 | 0.15 | 6.48 | 6.94 | 1.68 | 2.50 | 4.45 | 4.59 | 4.06 | 4.10 |
| Peru | 4.62 | 5.65 | 66.22 | 78.80 | 6.00 | 6.94 | 3.69 | 3.83 | 3.88 | 3.91 |
| Philippines | 17.21 | 20.22 | 73.12 | 85.91 | 25.05 | 28.03 | 3.62 | 3.63 | 3.36 | 3.40 |
| Poland | 64.91 | 72.11 | 124.02 | 153.29 | 47.04 | 47.99 | 3.81 | 3.94 | 4.40 | 4.46 |
| Russian Federation | 652.46 | 700.54 | 745.36 | 1,021.82 | 70.99 | 83.39 | 3.08 | 3.11 | 4.18 | 4.27 |
| Saudi Arabia | 477.78 | 563.50 | 300.66 | 367.85 | 133.18 | 143.74 | 4.32 | 4.42 | 4.80 | 4.92 |
| Singapore | 266.24 | 299.23 | 278.08 | 321.45 | 102.43 | 107.60 | 6.15 | 6.21 | 5.89 | 5.95 |
| South Africa | 386.75 | 407.56 | 651.44 | 737.00 | 56.70 | 58.10 | 4.42 | 4.46 | 4.00 | 4.06 |
| Spain | 2,230.00 | 2,570.71 | 1,209.45 | 1,422.95 | 168.83 | 180.61 | 5.08 | 5.25 | 4.85 | 4.88 |
| Sweden | 578.89 | 723.52 | 387.36 | 477.35 | 139.05 | 149.80 | 6.01 | 6.05 | 5.86 | 5.95 |
| Switzerland | 1,327.84 | 1,573.40 | 1,018.68 | 1,121.65 | 127.82 | 143.65 | 5.69 | 5.71 | 5.76 | 5.81 |
| Thailand | 114.63 | 121.31 | 129.29 | 152.65 | 74.70 | 86.67 | 4.26 | 4.36 | 4.28 | 4.33 |
| Turkey | 242.57 | 258.24 | 198.78 | 240.94 | 130.66 | 136.46 | 3.47 | 3.58 | 4.38 | 4.44 |
| Ukraine | 1.66 | 2.15 | 22.47 | 46.21 | 2.80 | 3.08 | 2.81 | 2.89 | 3.84 | 3.90 |
| United Kingdom | 5,715.85 | 7,446.35 | 2,560.32 | 3,061.96 | 206.74 | 237.66 | 5.73 | 5.87 | 5.42 | 5.50 |
| United States | 41,076.75 | 43,643.88 | 14,242.38 | 16,294.80 | 228.32 | 261.34 | 5.62 | 5.72 | 5.36 | 5.45 |

*L: Lower Bound Value; U: Upper Bound Value

## Table B.3: Lower and Upper Bounds of Variables for $\alpha = 0.75$ (continued)

| | Financial Stability | | Banking Financial Services | | Non-Banking Binancial Services | | GDP (Billion USD) | | GDP per Capita (USD) | |
|---|---|---|---|---|---|---|---|---|---|---|
| Country | L | U | L | U | L | U | L | U | L | U |
| Argentina | 3.16 | 3.35 | 2.83 | 2.87 | 2.43 | 2.48 | 295.56 | 312.01 | 7,371 | 7,767 |
| Australia | 5.19 | 5.28 | 4.79 | 5.02 | 4.19 | 4.29 | 907.84 | 953.49 | 41,874 | 43,834 |
| Austria | 4.81 | 5.06 | 4.23 | 4.26 | 1.94 | 2.00 | 378.89 | 389.48 | 45,384 | 46,606 |
| Belgium | 4.79 | 4.93 | 4.69 | 4.81 | 2.42 | 2.50 | 468.03 | 479.71 | 43,544 | 44,552 |
| Brazil | 4.75 | 5.14 | 3.03 | 3.28 | 3.11 | 3.29 | 1,521.55 | 1,589.54 | 7,887 | 8,224 |
| Canada | 5.20 | 5.34 | 4.81 | 4.91 | 4.28 | 4.40 | 1,402.07 | 1,442.83 | 42,288 | 43,639 |
| Chile | 5.15 | 5.44 | 3.38 | 3.50 | 1.82 | 1.86 | 164.15 | 165.95 | 9,819 | 9,950 |
| China | 4.91 | 4.99 | 4.88 | 4.93 | 3.31 | 3.60 | 4,264.89 | 4,637.74 | 3,223 | 3,496 |
| Colombia | 4.40 | 4.53 | 2.63 | 2.82 | 1.83 | 1.93 | 227.37 | 236.18 | 5,013 | 5,192 |
| Czech Republic | 4.67 | 4.86 | 3.62 | 3.86 | 1.46 | 1.54 | 186.26 | 196.73 | 17,819 | 18,786 |
| Egypt | 4.06 | 4.30 | 3.08 | 3.17 | 2.04 | 2.15 | 154.75 | 169.23 | 1,905 | 2,066 |
| Finland | 5.20 | 5.25 | 3.61 | 3.86 | 2.14 | 2.18 | 243.96 | 252.08 | 46,024 | 47,605 |
| France | 5.16 | 5.20 | 4.08 | 4.21 | 3.83 | 4.31 | 2,635.55 | 2,700.60 | 40,949 | 41,906 |
| Germany | 5.19 | 5.45 | 4.31 | 4.46 | 3.50 | 3.67 | 3,329.81 | 3,406.16 | 40,619 | 41,568 |
| Hungary | 3.35 | 3.55 | 2.33 | 2.64 | 1.51 | 1.64 | 136.31 | 142.73 | 13,566 | 14,201 |
| India | 4.18 | 4.34 | 2.95 | 3.08 | 3.21 | 3.31 | 1,228.17 | 1,252.16 | 1,088 | 1,106 |
| Indonesia | 4.21 | 4.40 | 2.63 | 3.12 | 1.87 | 1.99 | 490.90 | 517.95 | 2,165 | 2,271 |
| Ireland | 4.26 | 4.72 | 4.94 | 5.00 | 3.17 | 3.19 | 251.58 | 261.36 | 57,468 | 59,750 |
| Israel | 4.48 | 4.55 | 3.94 | 4.02 | 2.13 | 2.22 | 188.29 | 197.07 | 25,507 | 26,605 |
| Italy | 4.40 | 4.54 | 4.10 | 4.20 | 2.79 | 2.95 | 2,115.35 | 2,161.31 | 35,502 | 36,327 |
| Japan | 4.54 | 4.86 | 5.09 | 5.16 | 4.11 | 4.23 | 4,759.71 | 4,932.48 | 37,267 | 38,635 |
| Kazakhstan | 3.56 | 3.64 | 2.78 | 2.91 | 2.75 | 3.00 | 112.69 | 119.84 | 7,136 | 7,571 |
| Korea | 4.35 | 4.50 | 4.11 | 4.32 | 3.47 | 3.75 | 906.68 | 960.86 | 18,641 | 19,785 |
| Kuwait | 5.31 | 5.45 | 3.78 | 3.83 | 1.12 | 1.21 | 110.66 | 123.06 | 41,119 | 45,880 |
| Malaysia | 5.17 | 5.31 | 4.69 | 4.96 | 2.31 | 2.62 | 191.48 | 200.28 | 7,029 | 7,325 |
| Mexico | 4.91 | 5.02 | 2.54 | 2.61 | 1.96 | 1.99 | 987.89 | 1,041.66 | 9,342 | 9,868 |
| Netherlands | 4.81 | 5.12 | 4.74 | 5.01 | 3.82 | 3.93 | 788.67 | 812.31 | 47,815 | 49,207 |
| Nigeria | 3.78 | 4.19 | 2.45 | 2.54 | 1.26 | 1.32 | 171.23 | 181.53 | 1,122 | 1,185 |
| Norway | 5.64 | 5.77 | 4.30 | 4.33 | 2.23 | 2.29 | 386.09 | 403.38 | 81,493 | 85,363 |
| Panama | 3.82 | 4.21 | 3.97 | 4.04 | 1.64 | 1.73 | 22.34 | 23.57 | 6,596 | 6,905 |
| Peru | 4.56 | 4.84 | 2.68 | 2.74 | 1.62 | 1.74 | 123.70 | 129.41 | 4,294 | 4,471 |
| Philippines | 3.92 | 4.19 | 2.72 | 2.80 | 1.80 | 1.90 | 156.91 | 162.55 | 1,720 | 1,775 |
| Poland | 4.44 | 4.61 | 3.16 | 3.18 | 1.73 | 1.89 | 428.89 | 454.64 | 11,244 | 11,919 |
| Russian Federation | 4.35 | 4.43 | 1.99 | 2.26 | 4.03 | 4.17 | 1,282.76 | 1,391.52 | 9,031 | 9,796 |
| Saudi Arabia | 5.88 | 6.01 | 3.57 | 3.70 | 1.40 | 1.56 | 380.35 | 406.83 | 15,520 | 16,673 |
| Singapore | 5.65 | 5.80 | 4.39 | 4.65 | 3.26 | 3.43 | 180.87 | 185.01 | 38,026 | 38,880 |
| South Africa | 4.64 | 4.68 | 3.73 | 3.84 | 2.35 | 2.51 | 283.14 | 285.60 | 5,756 | 5,823 |
| Spain | 4.48 | 4.75 | 5.01 | 5.11 | 3.54 | 3.67 | 1,455.40 | 1,493.81 | 32,022 | 32,829 |
| Sweden | 4.96 | 5.12 | 4.38 | 4.66 | 2.60 | 2.72 | 448.40 | 468.78 | 48,832 | 51,140 |
| Switzerland | 5.66 | 5.79 | 4.34 | 4.53 | 2.93 | 3.04 | 477.47 | 494.55 | 62,094 | 64,146 |
| Thailand | 4.56 | 4.61 | 3.54 | 3.78 | 1.60 | 1.67 | 259.61 | 265.94 | 3,842 | 3,930 |
| Turkey | 3.47 | 3.72 | 3.04 | 3.13 | 1.88 | 1.97 | 639.02 | 667.95 | 8,702 | 9,119 |
| Ukraine | 3.07 | 3.15 | 2.56 | 2.75 | 2.29 | 2.41 | 135.43 | 152.13 | 2,918 | 3,276 |
| United Kingdom | 4.43 | 4.67 | 5.35 | 5.40 | 6.15 | 6.41 | 2,540.62 | 2,696.75 | 41,312 | 43,996 |
| United States | 4.49 | 4.80 | 4.16 | 4.61 | 6.02 | 6.06 | 14,104.70 | 14,181.53 | 46,468 | 46,772 |

*L: Lower Bound Value; U: Upper Bound Value

**APPENDIX C: Efficiency Scores of Countries in Fuzzy Data Envelopment (FDEA) and Average of Classical Data Envelopment (DEA) Results of Countries**

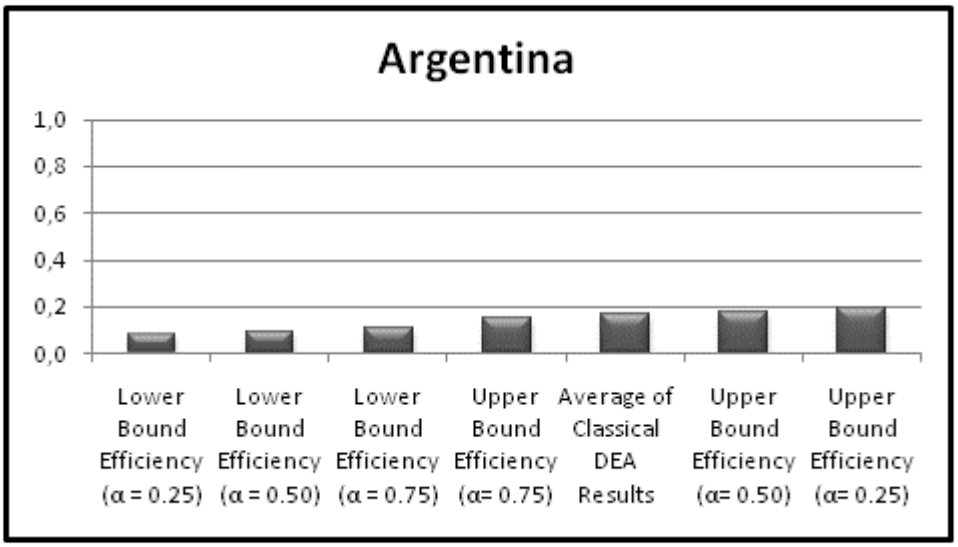


**Figure C.1: FDEA and DEA Efficiency Scores for Argentina**

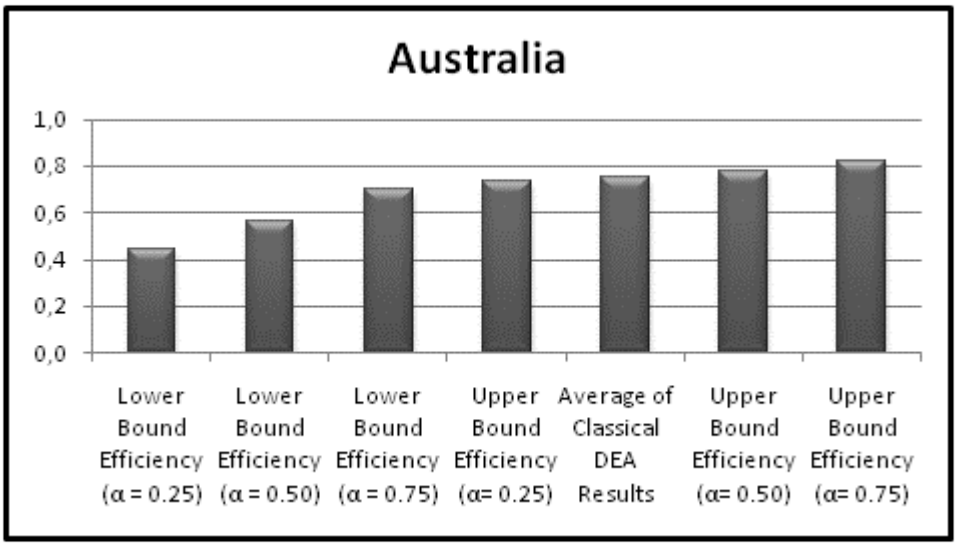


**Figure C.2: FDEA and DEA Efficiency Scores for Australia**

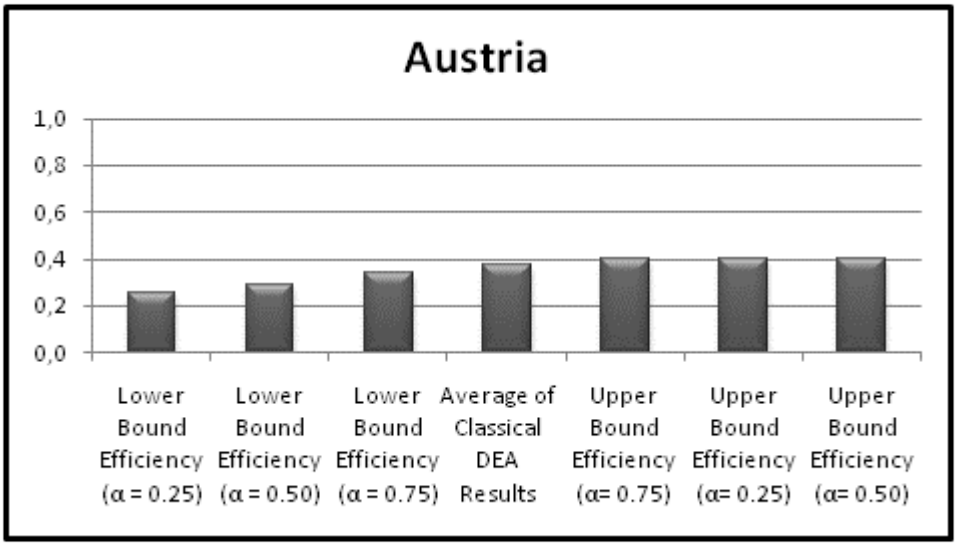


**Figure C.3: FDEA and DEA Efficiency Scores for Austria**

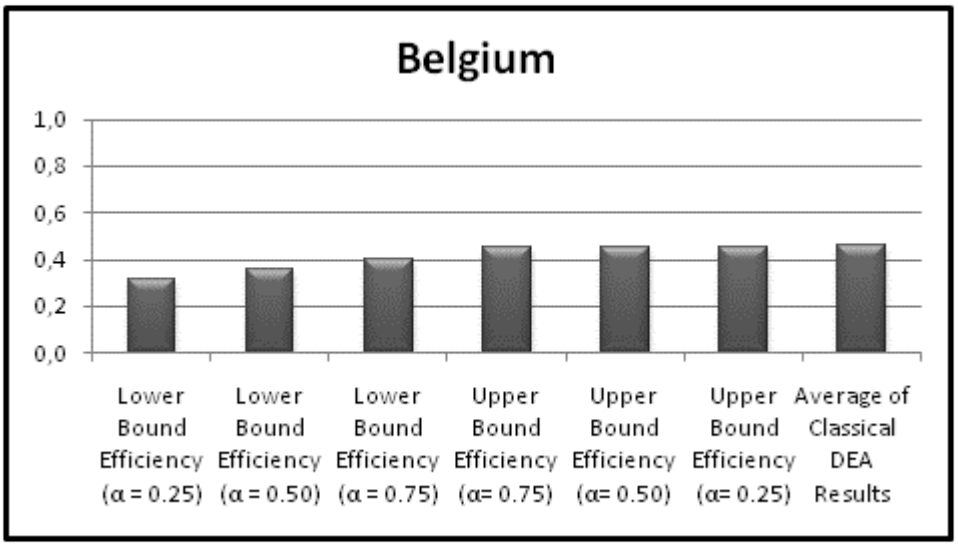


**Figure C.4: FDEA and DEA Efficiency Scores for Belgium**

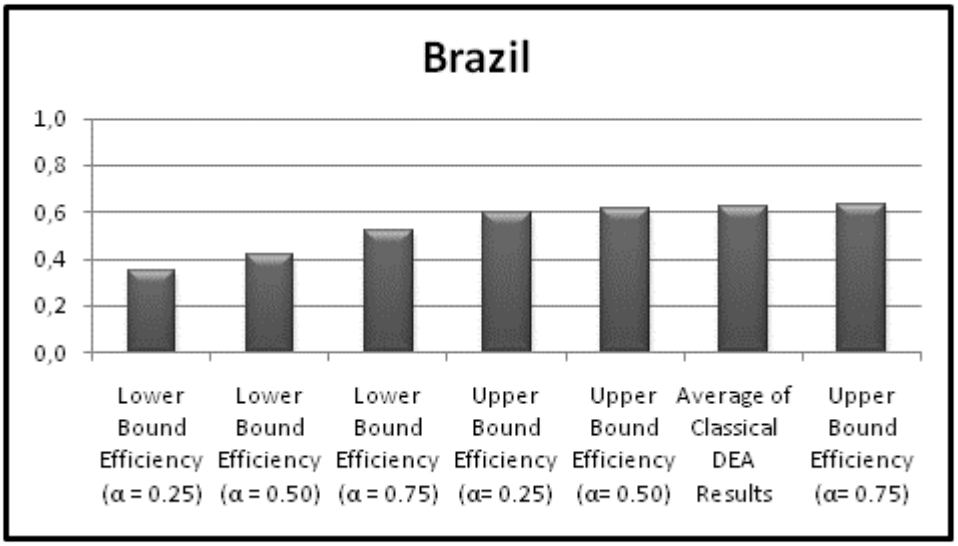


**Figure C.5: FDEA and DEA Efficiency Scores for Brazil**

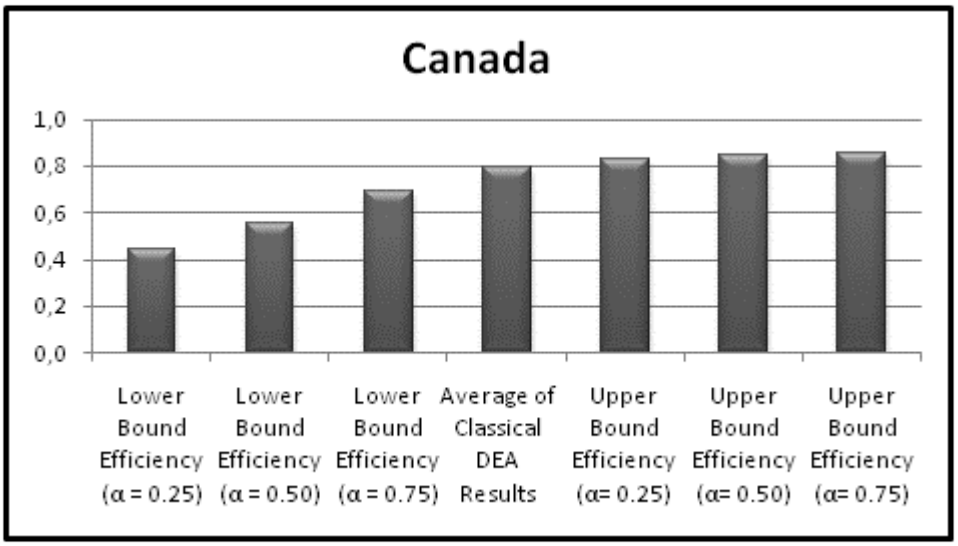


**Figure C.6: FDEA and DEA Efficiency Scores for Canada**

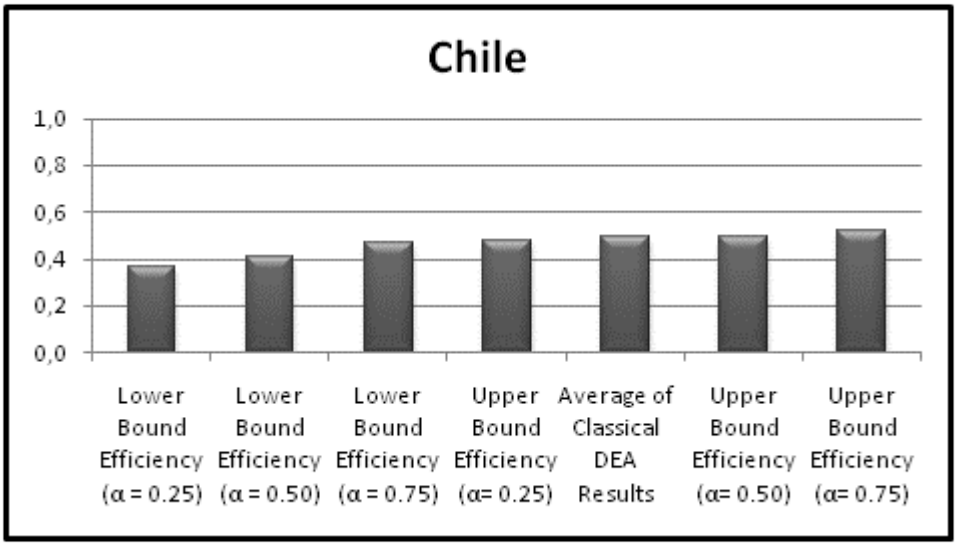


**Figure C.7: FDEA and DEA Efficiency Scores for Chile**

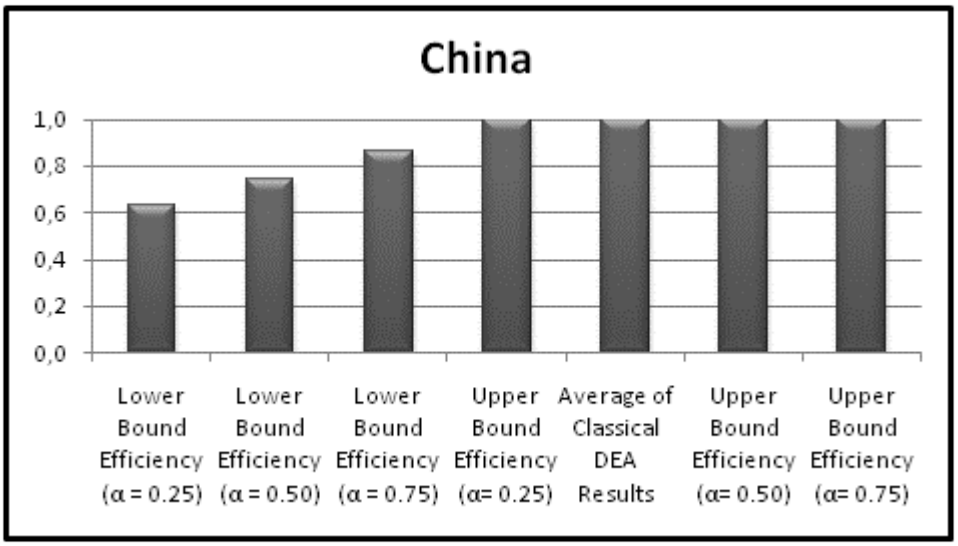


**Figure C.8: FDEA and DEA Efficiency Scores for China**

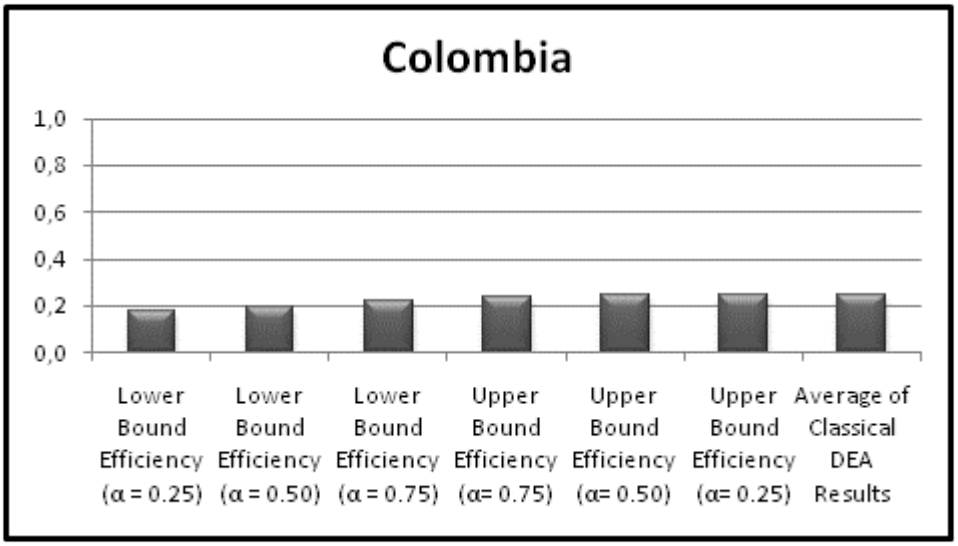


**Figure C.9: FDEA and DEA Efficiency Scores for Colombia**

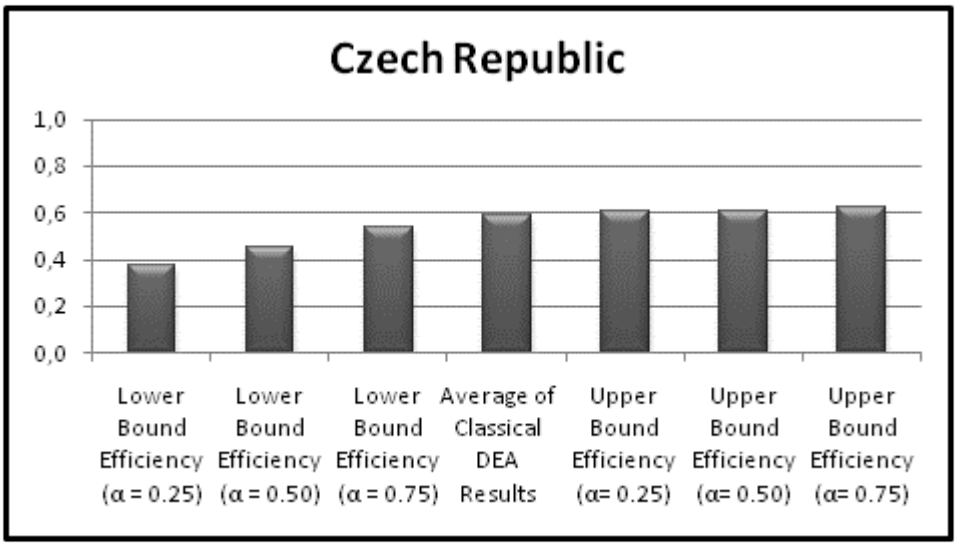


**Figure C.10: FDEA and DEA Efficiency Scores for Czech Republic**

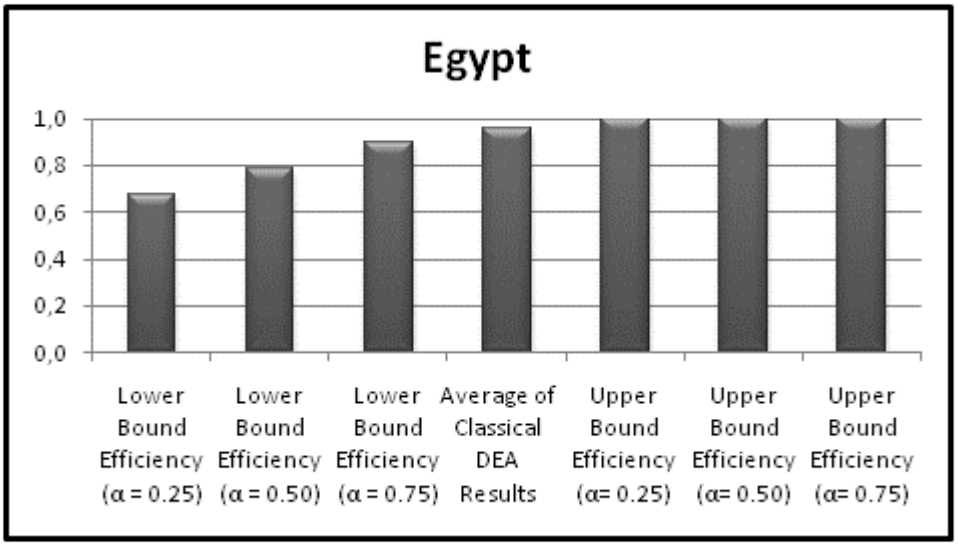


**Figure C.11: FDEA and DEA Efficiency Scores for Egypt**

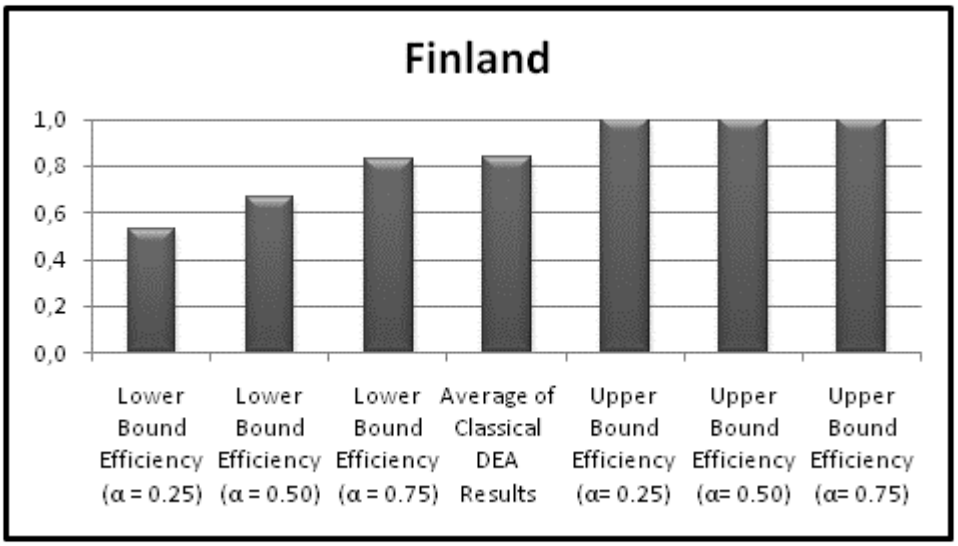


**Figure C.12: FDEA and DEA Efficiency Scores for Finland**

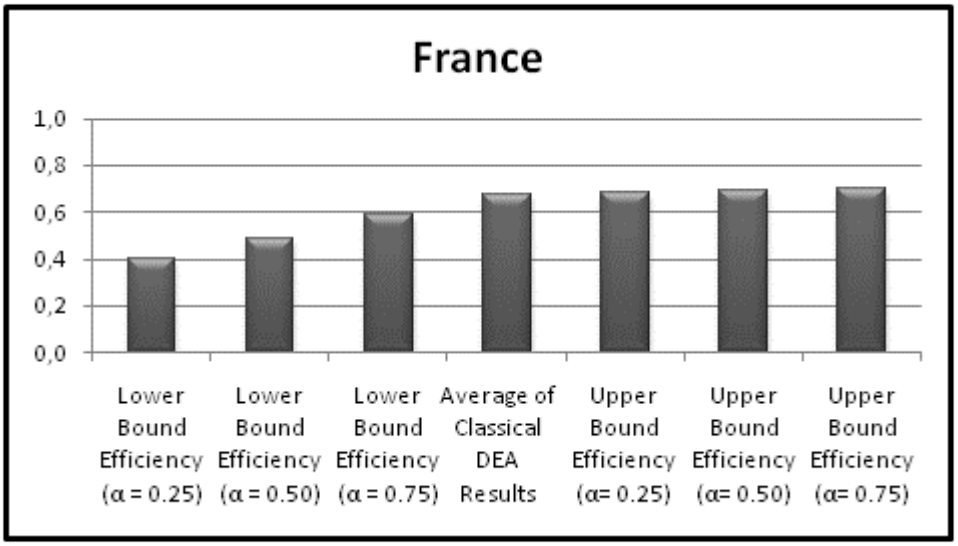


**Figure C.13: FDEA and DEA Efficiency Scores for France**

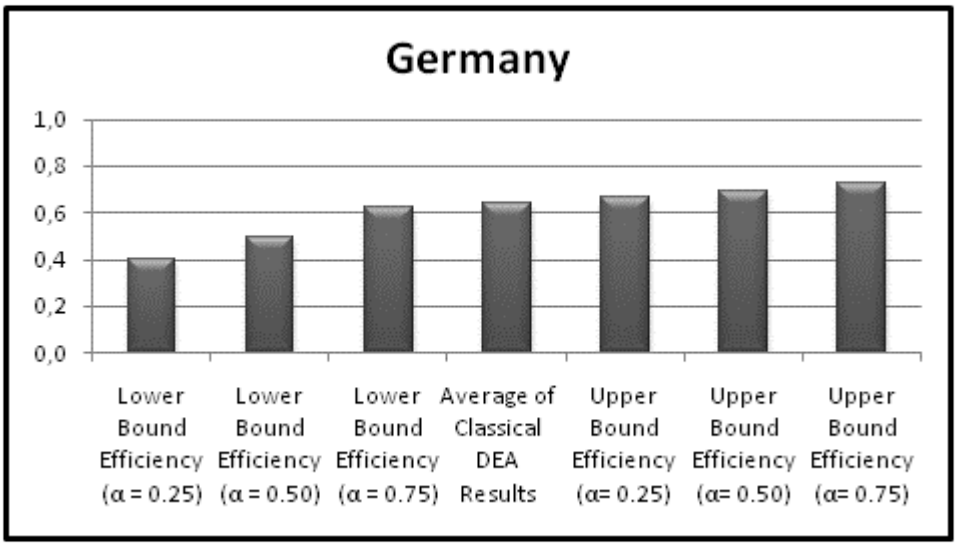


**Figure C.14: FDEA and DEA Efficiency Scores for Germany**

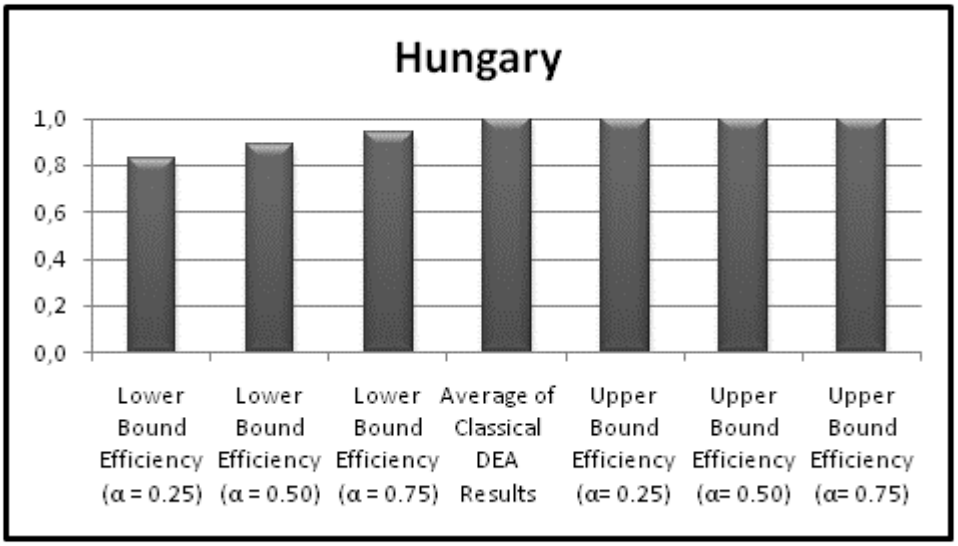


**Figure C.15: FDEA and DEA Efficiency Scores for Hungary**

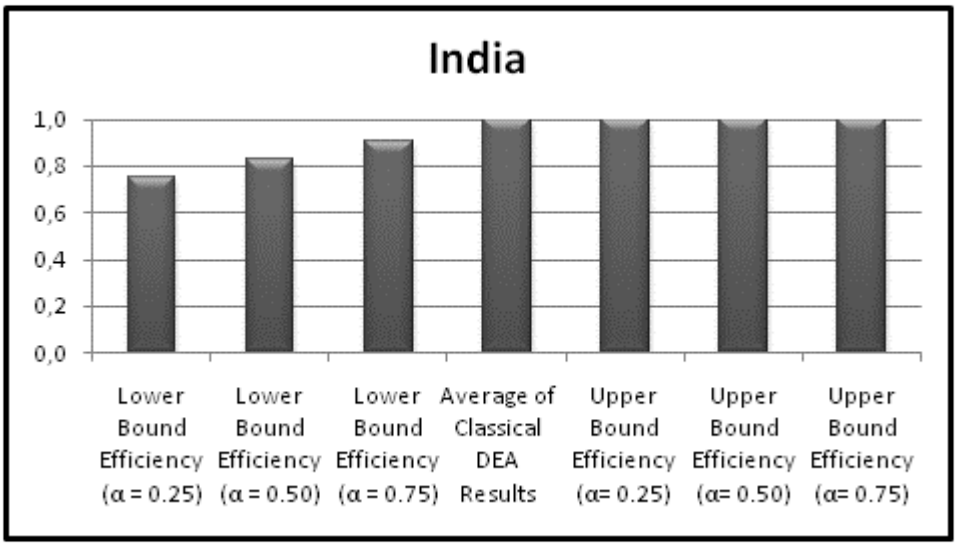


**Figure C.16: FDEA and DEA Efficiency Scores for India**

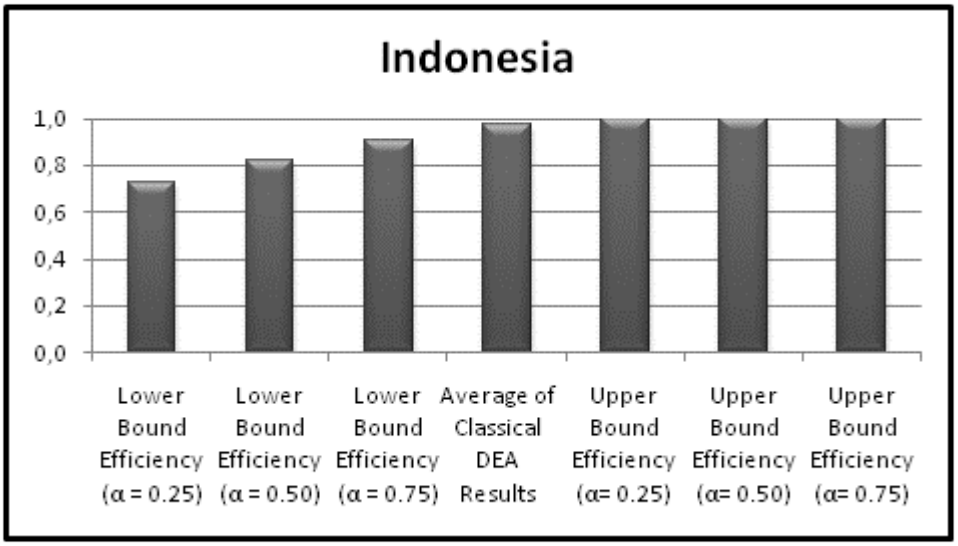


**Figure C.17: FDEA and DEA Efficiency Scores for Indonesia**

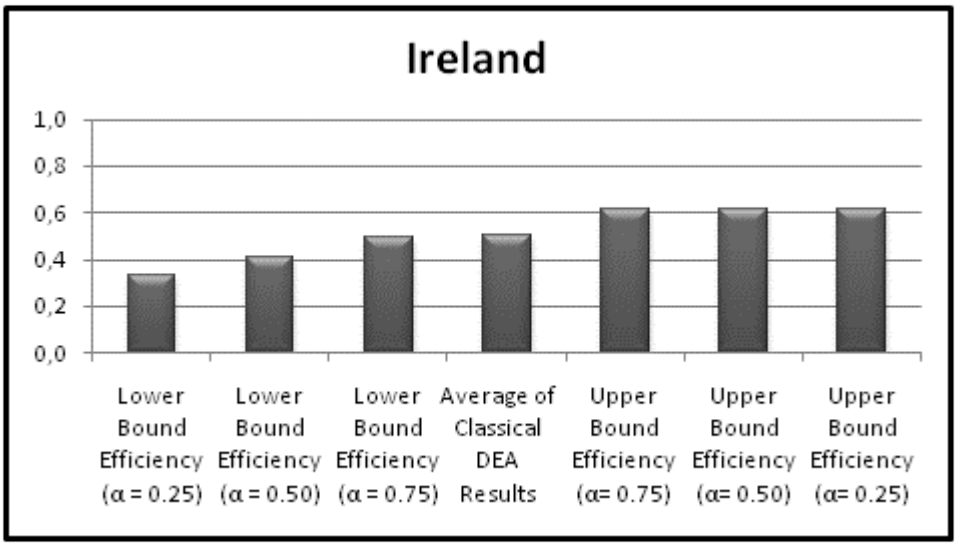


**Figure C.18: FDEA and DEA Efficiency Scores for Ireland**

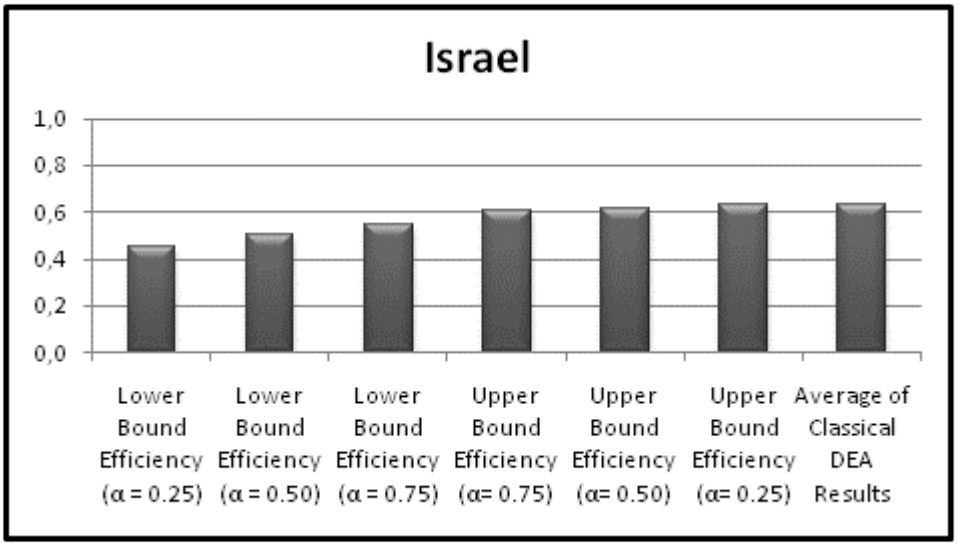


**Figure C.19: FDEA and DEA Efficiency Scores for Israel**

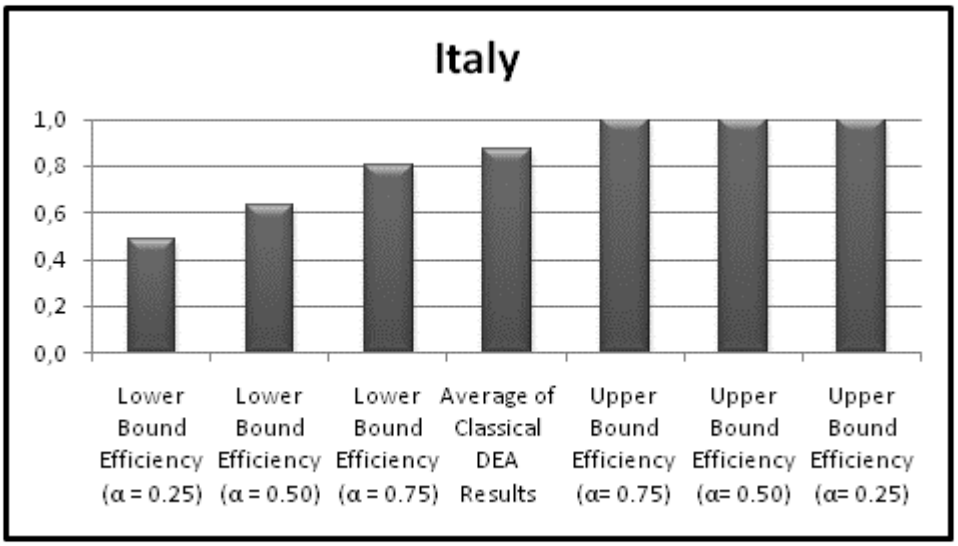


**Figure C.20: FDEA and DEA Efficiency Scores for Italy**

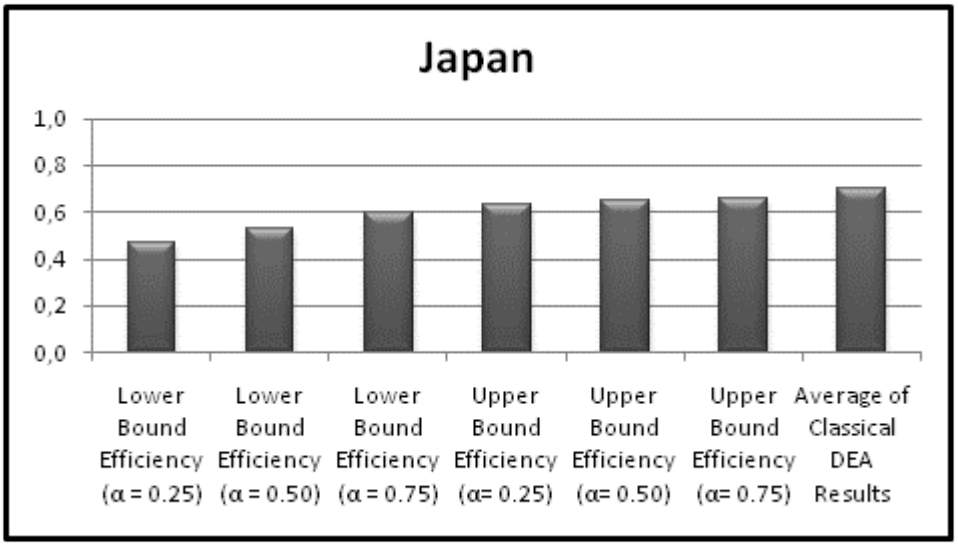


**Figure C.21: FDEA and DEA Efficiency Scores for Japan**

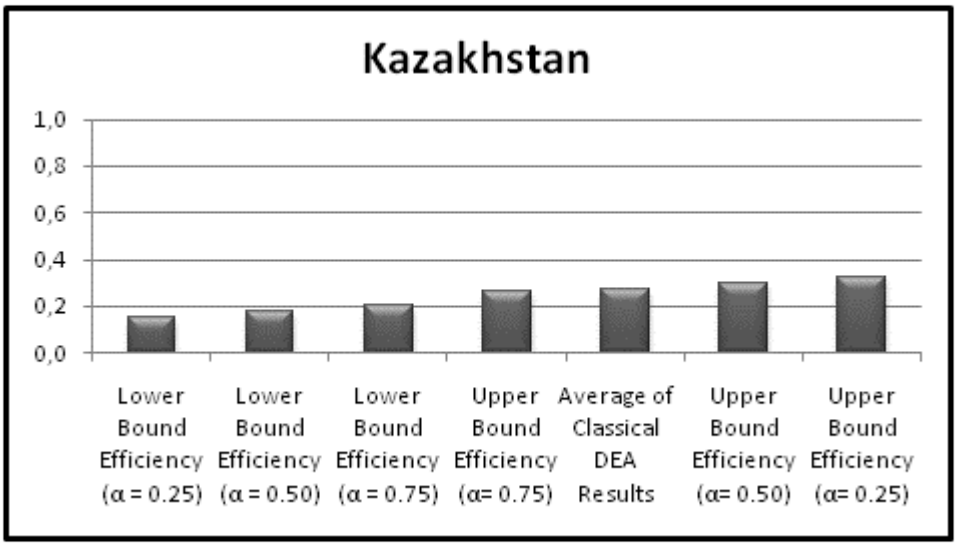


**Figure C.22: FDEA and DEA Efficiency Scores for Kazakhstan**

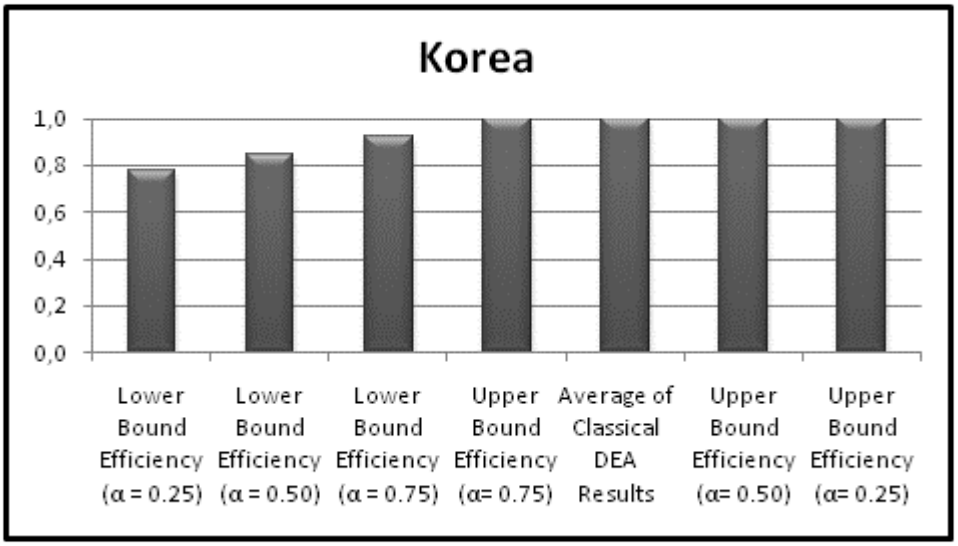


**Figure C.23: FDEA and DEA Efficiency Scores for Korea**

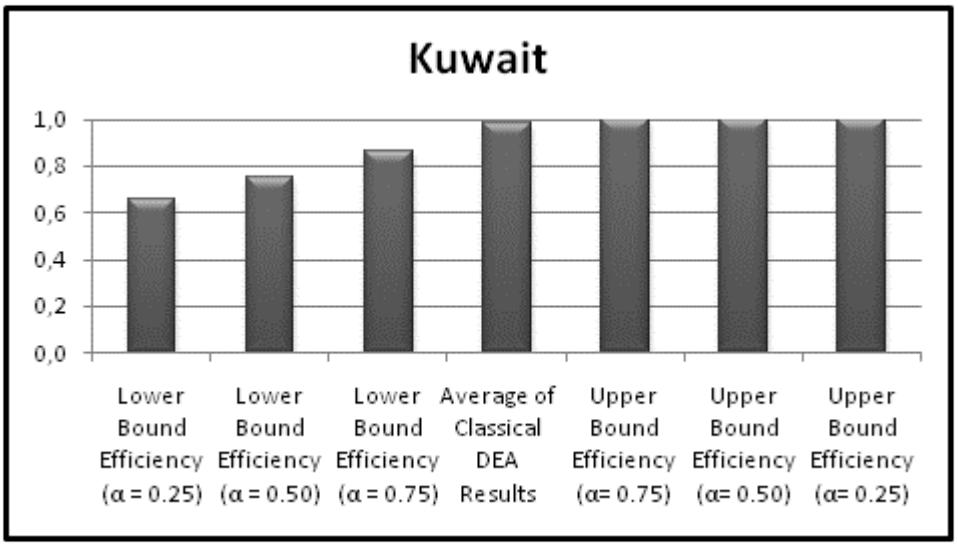


**Figure C.24: FDEA and DEA Efficiency Scores for Kuwait**

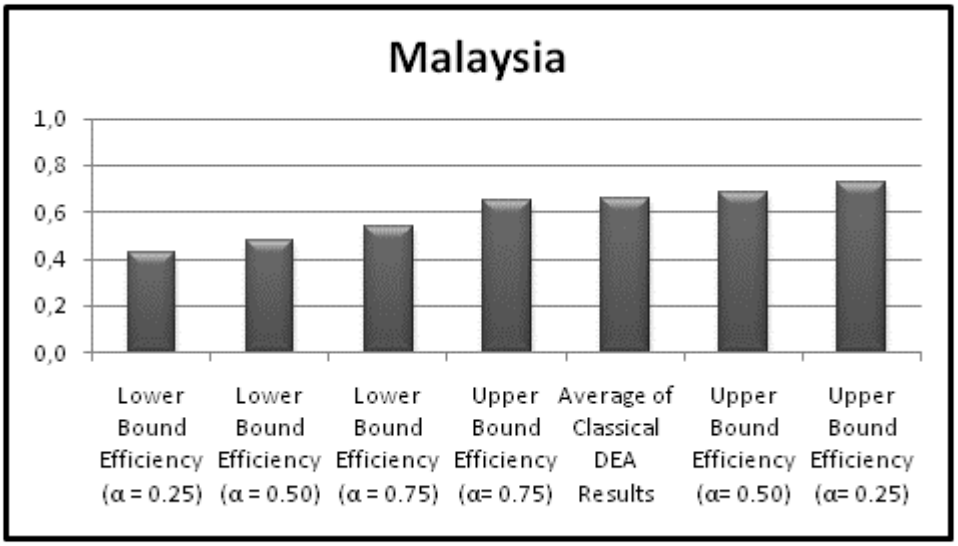


**Figure C.25: FDEA and DEA Efficiency Scores for Malaysia**

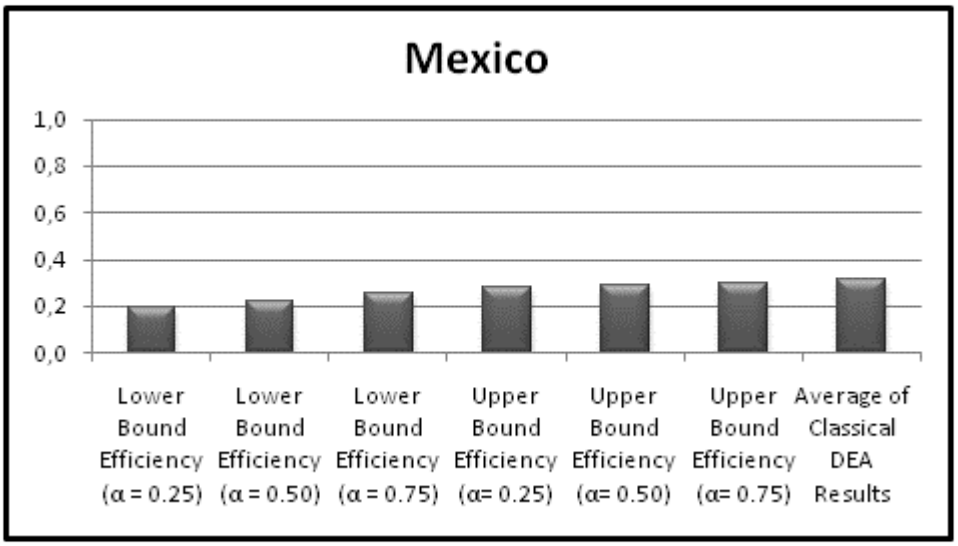


**Figure C.26: FDEA and DEA Efficiency Scores for Mexico**

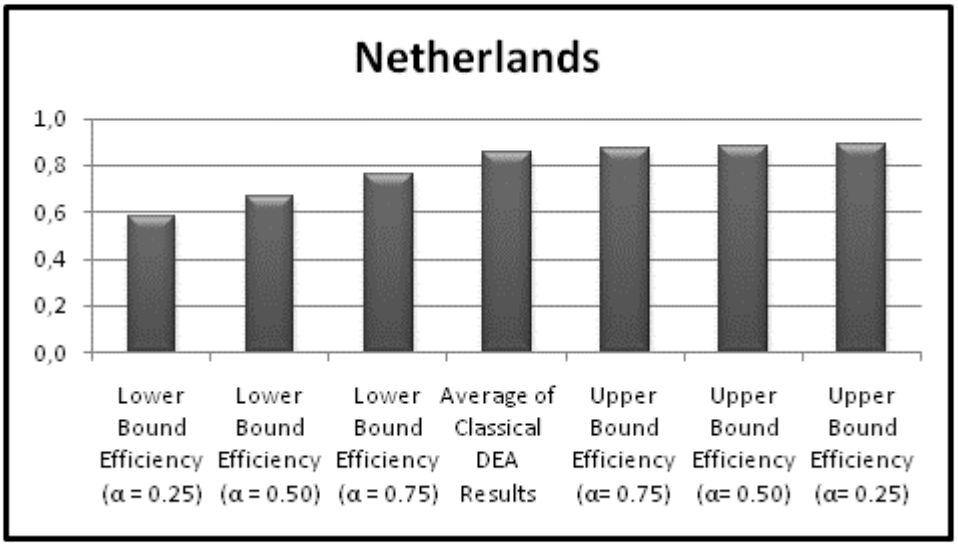


**Figure C.27: FDEA and DEA Efficiency Scores for Netherlands, The**

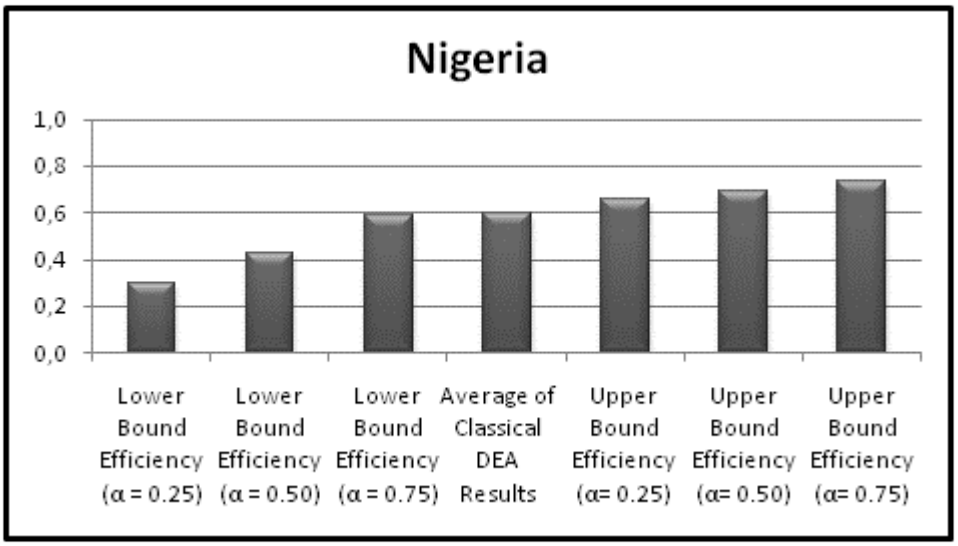


**Figure C.28: FDEA and DEA Efficiency Scores for Nigeria**

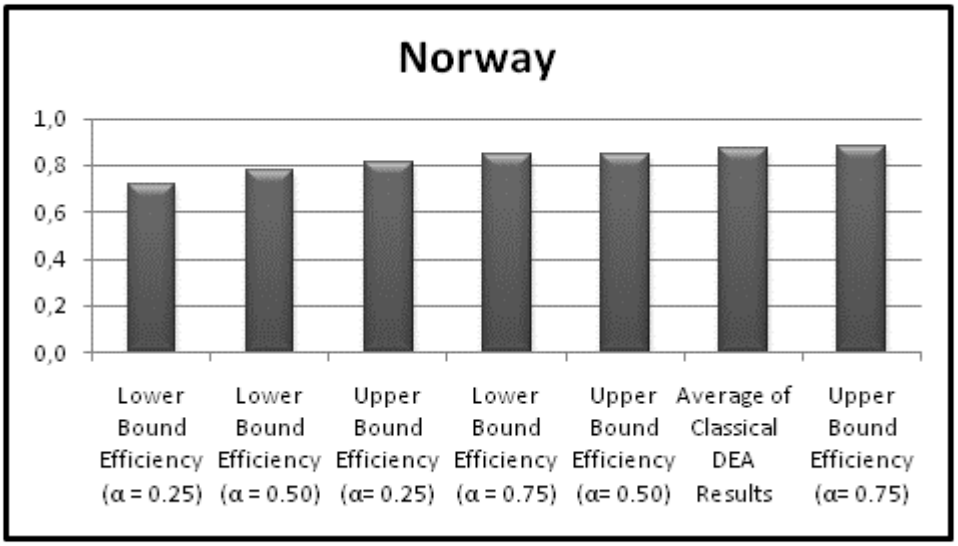


**Figure C.29: FDEA and DEA Efficiency Scores for Norway**

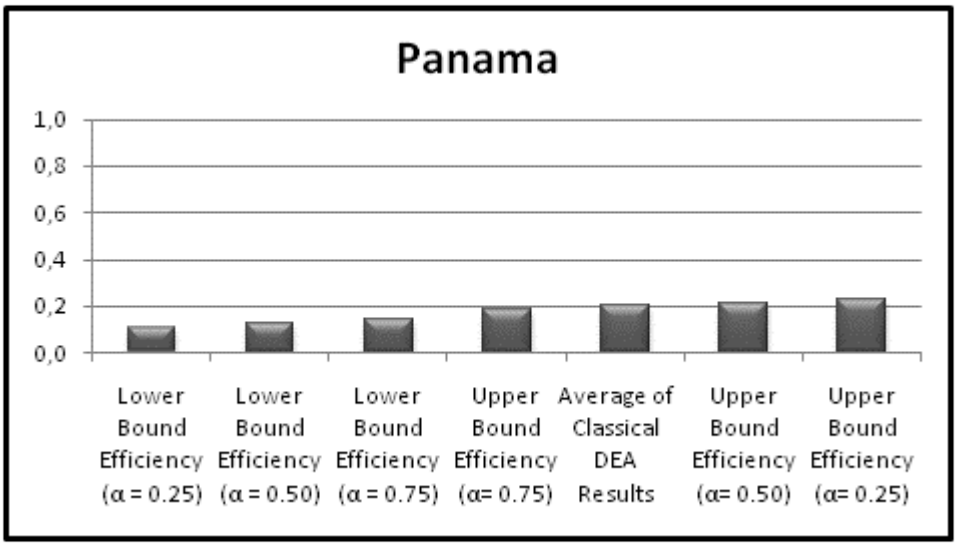


**Figure C.30: FDEA and DEA Efficiency Scores for Panama**

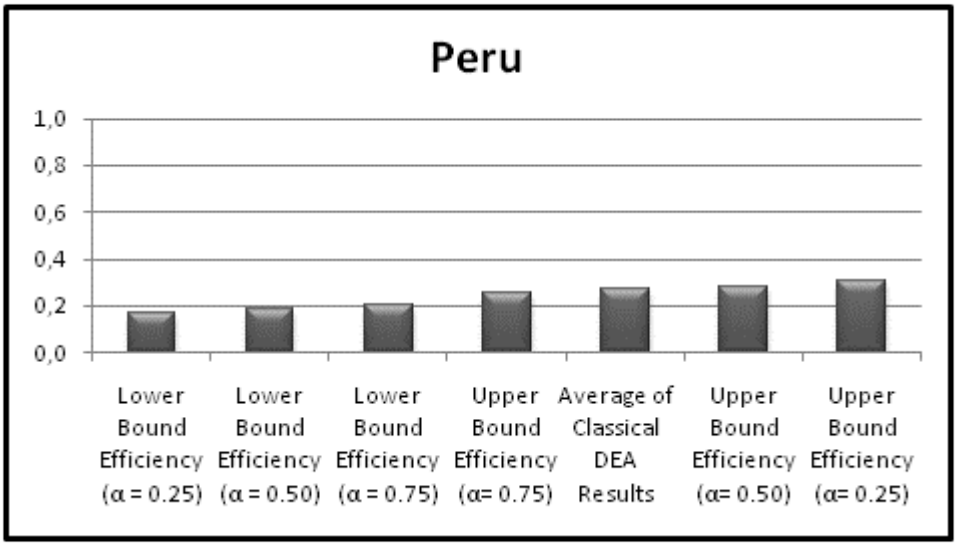


**Figure C.31: FDEA and DEA Efficiency Scores for Peru**

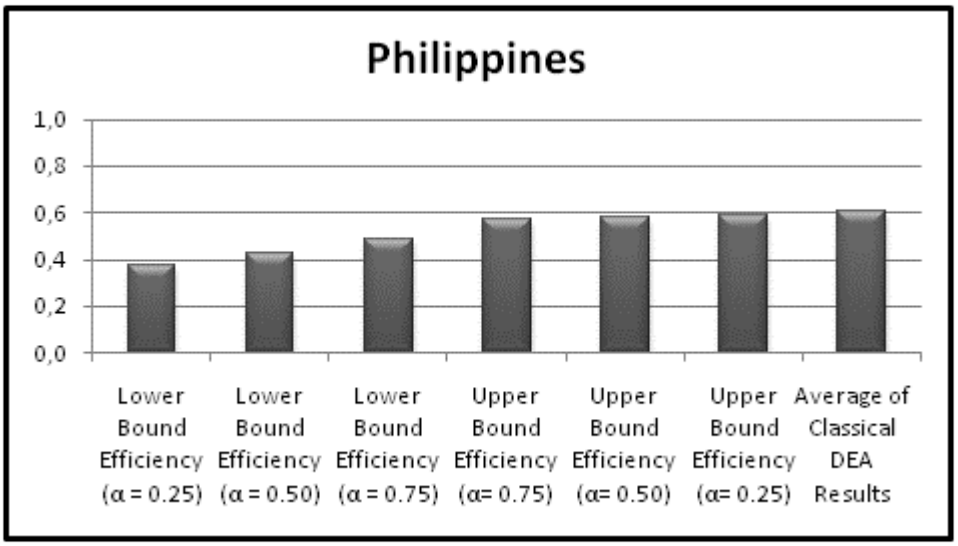


**Figure C.32: FDEA and DEA Efficiency Scores for Philippines**

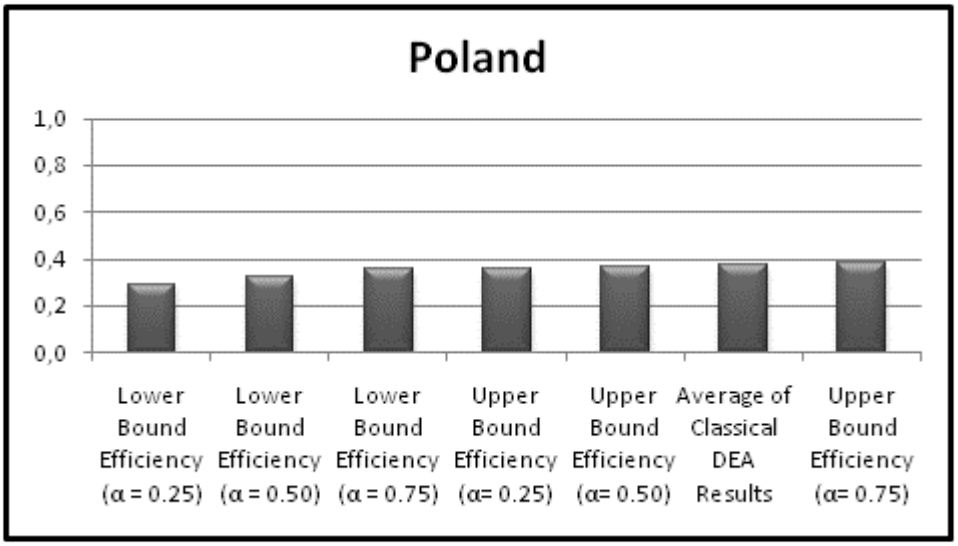


**Figure C.33: FDEA and DEA Efficiency Scores for Poland**

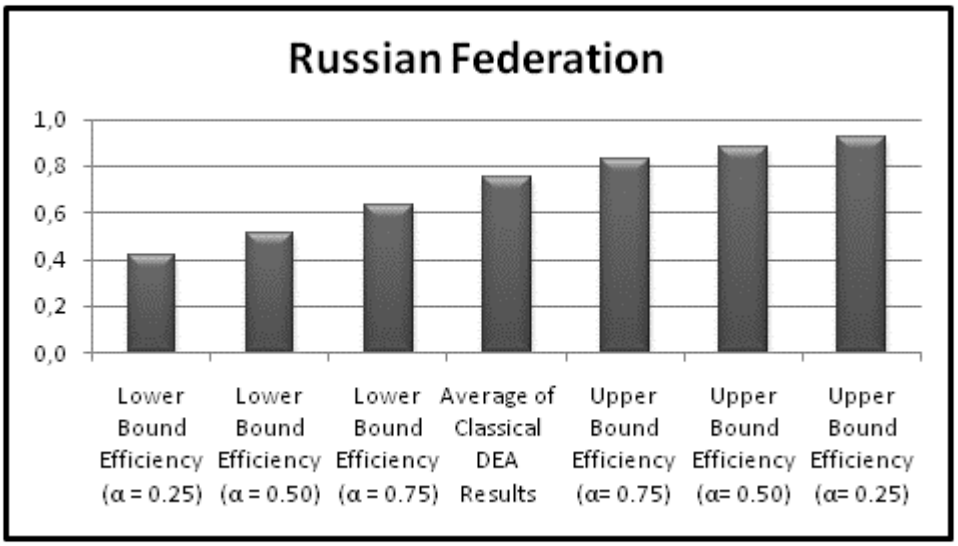


**Figure C.34: FDEA and DEA Efficiency Scores for Russian Federation**

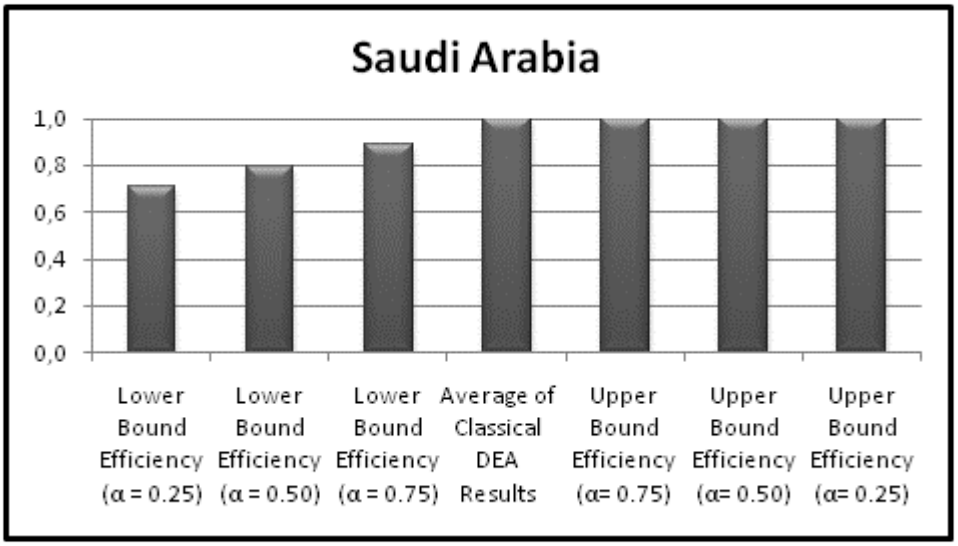


**Figure C.35: FDEA and DEA Efficiency Scores for Saudi Arabia**

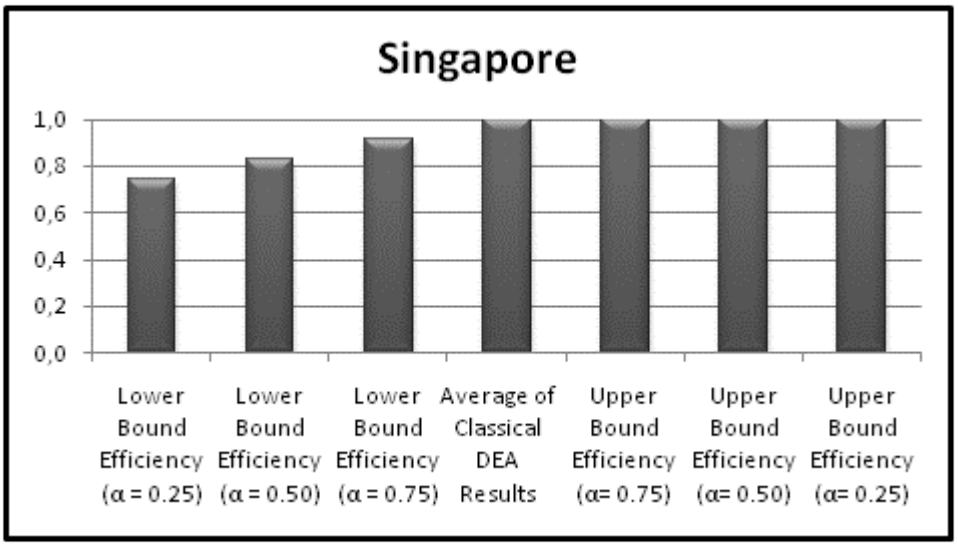


**Figure C.36: FDEA and DEA Efficiency Scores for Singapore**

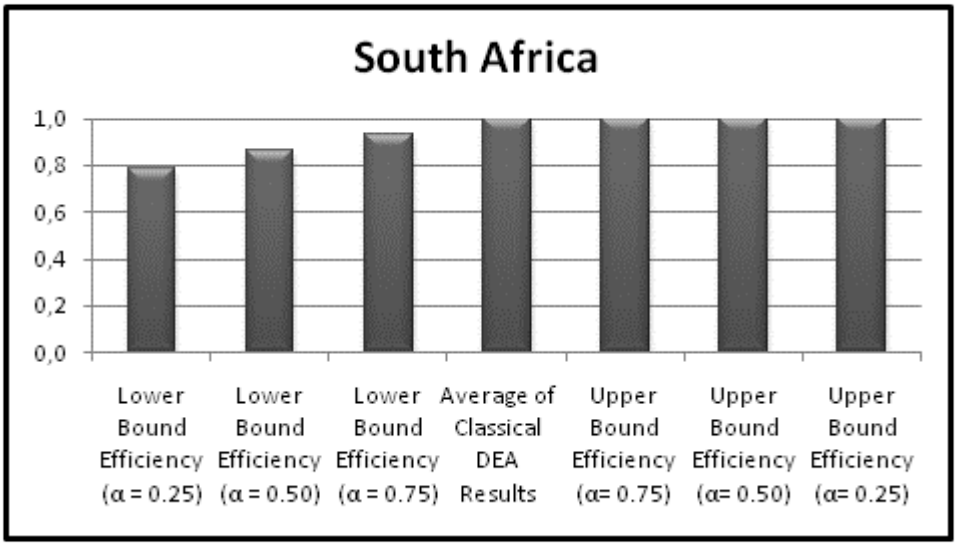


**Figure C.37: FDEA and DEA Efficiency Scores for South Africa**

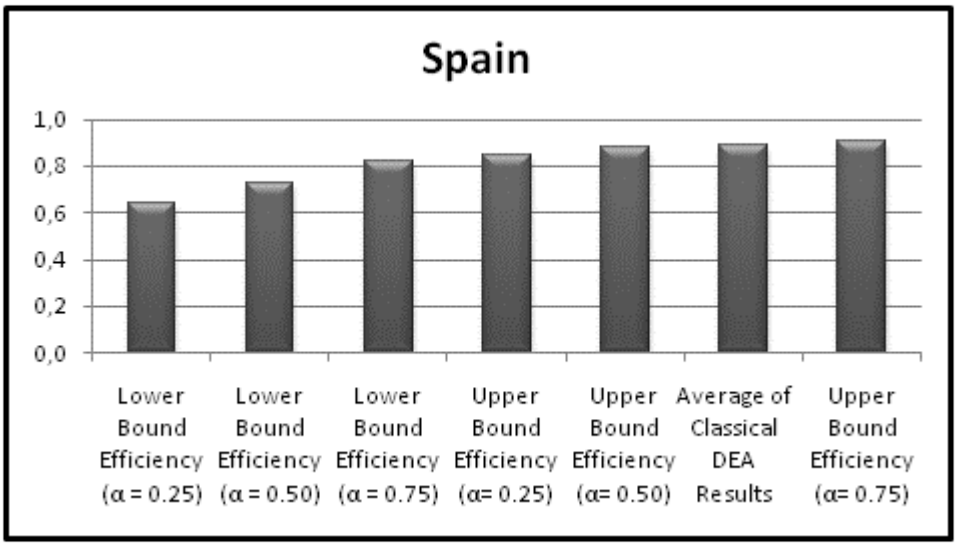


**Figure C.38: FDEA and DEA Efficiency Scores for Spain**

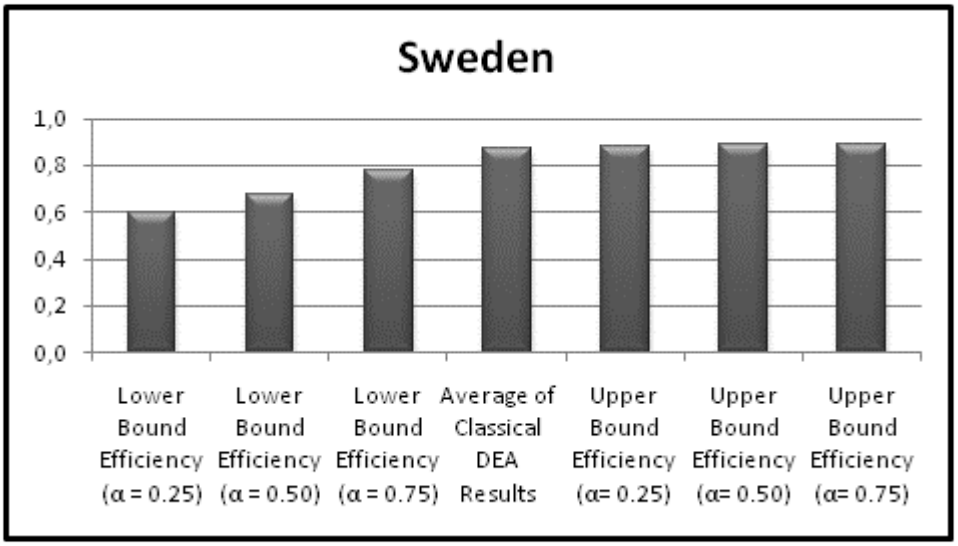


**Figure C.39: FDEA and DEA Efficiency Scores for Sweden**

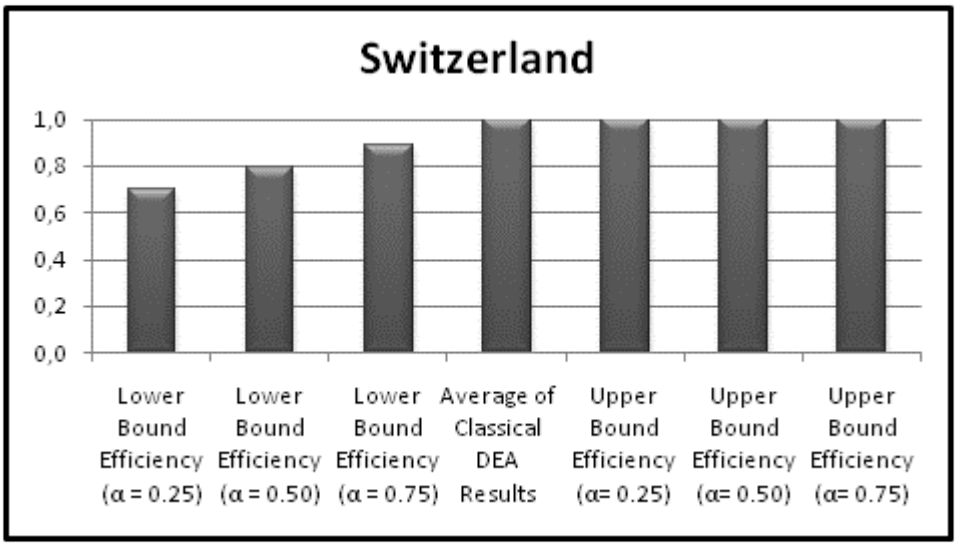


**Figure C.40: FDEA and DEA Efficiency Scores for Switzerland**

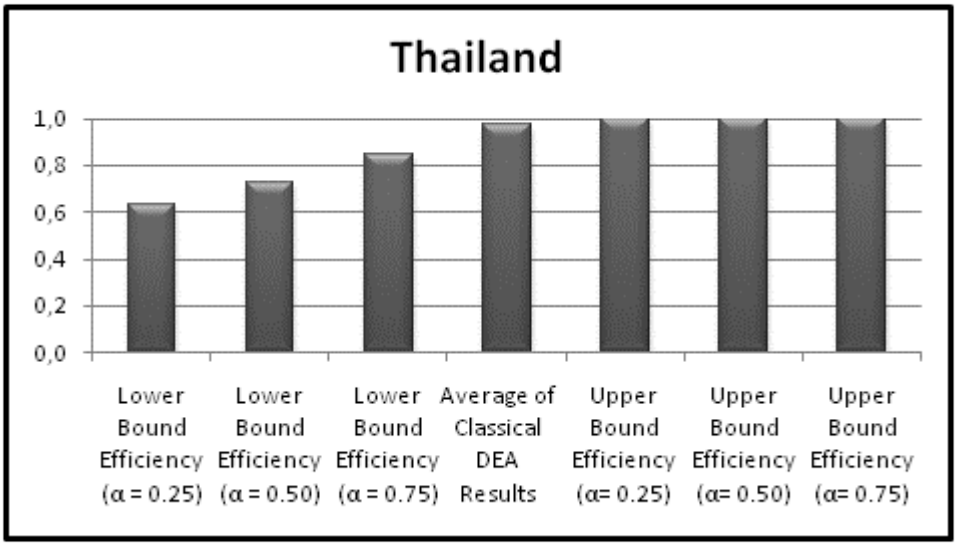


**Figure C.41: FDEA and DEA Efficiency Scores for Thailand**

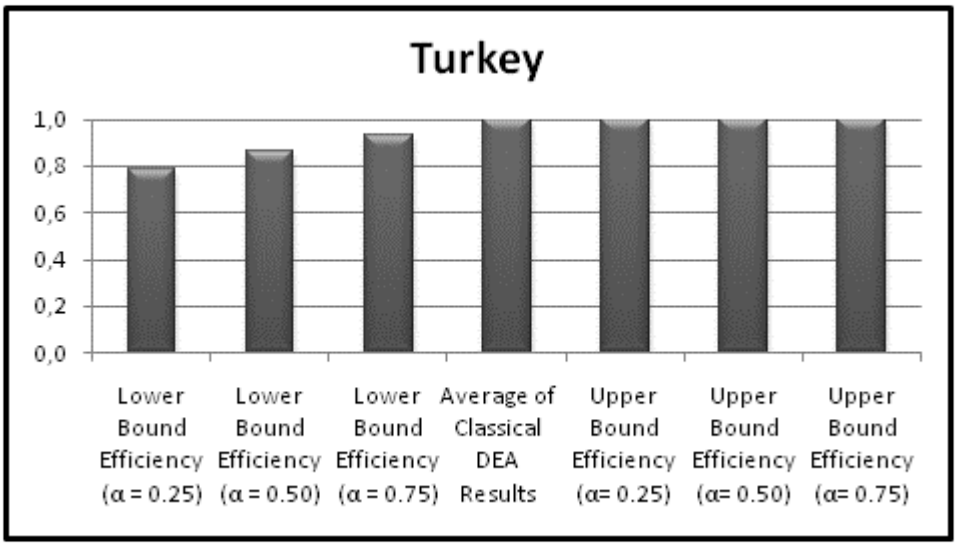


**Figure C.42: FDEA and DEA Efficiency Scores for Turkey**

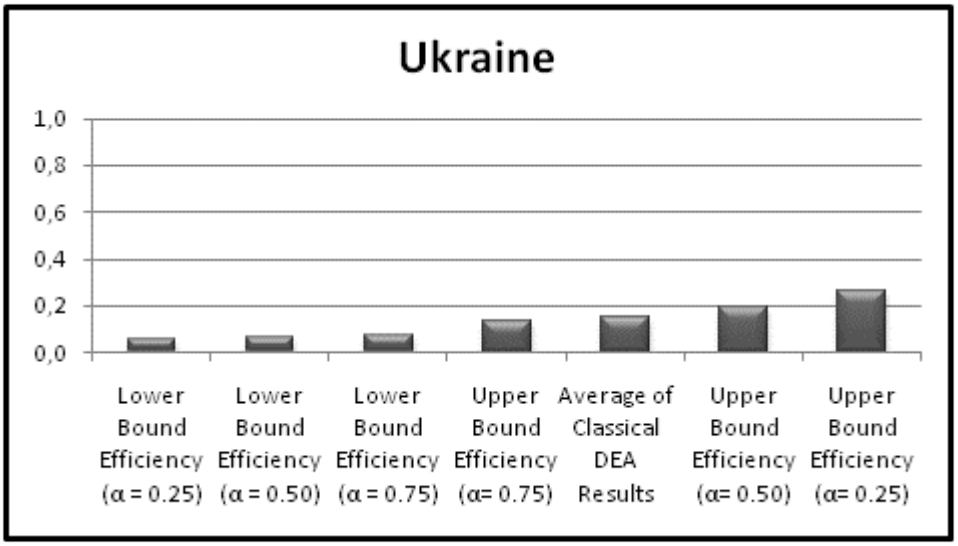


**Figure C.43: FDEA and DEA Efficiency Scores for Ukraine**

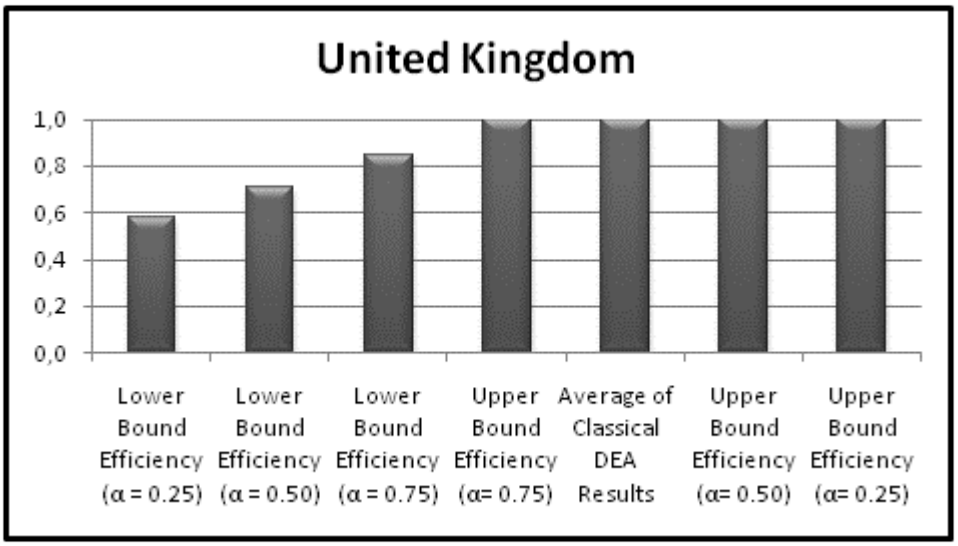


**Figure C.44: FDEA and DEA Efficiency Scores for United Kingdom**

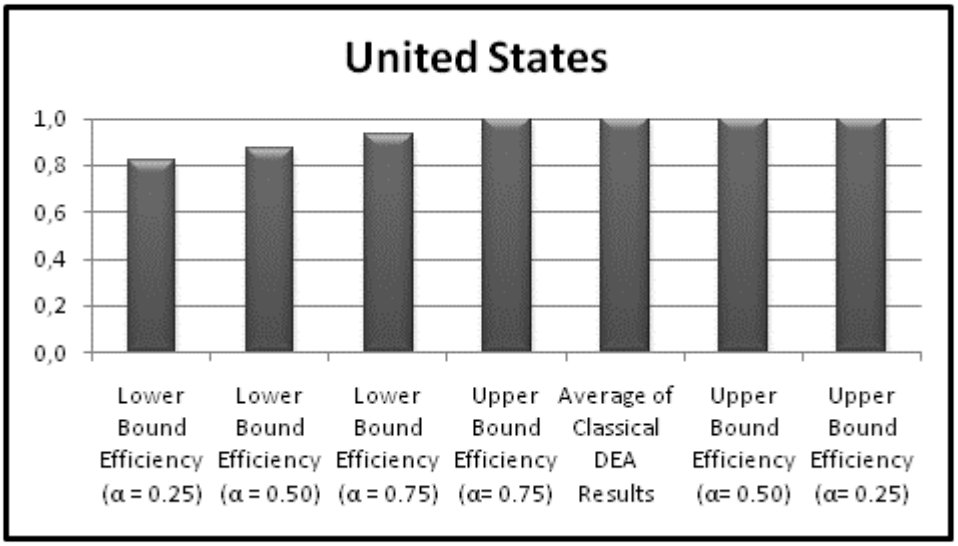


**Figure C.45: FDEA and DEA Efficiency Scores for United Staes**

# CURRICULUM VITAE

**Name Surname:** HAKAN BALKAN

**Address:** İstinye Mahallesi Boğaziçi Caddesi No: 19/11- Sarıyer / İstanbul

**E-mail:** balkanhakan@yahoo.com

**Place and Date of Birth:** Adana – February 27, 1979

**Primary Education:** Osmangazi Primary School – İstanbul - 1993

**Secondary Education:** Gündoğdu High School – Adana - 1996

**Bachelor of Science:** Marmara University - Industrial Engineering - 2002

**Master of Science:** Bahçeşehir University

**Name of Institution:** The Graduate School of Natural and Applied Sciences

**Name of Program:** Industrial Engineering

**Marital Status:** Married with a son

**Working Life:** Human Resources Specialist in Istanbul Stock Exchange since 2008