An application of SFA and DEA in the Albanian Banking Sector

by

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Abstract

Banking sector is the main financial sector in developing countries. Due to its significant role in the economy of the entire country, analysis should be done in order to see its performance. This thesis aims to provide information about the efficiency of the main banks operating in the Albanian banking sector during the period 2006-2014. The literature suggests two different methods to measure the efficiency of banks; a non-parametric approach (mathematical method), named DEA-data envelopment analysis and a parametric approach (econometric method) called SFA-stochastic frontier analysis. The previous studies and research done for the Albanian banking system use *one* of the methods mentioned above. While, this thesis uses both methods DEA and SFA and also compares the obtained results for each method in order to verify the robustness of outcomes. Using DEA method we measured the technical efficiency while, using SFA we estimated the cost and technical efficiency of the main banks. The results show low scores for cost efficiency and high score for technical efficiency. The most important factors that have a significant role in the efficiency of the Albanian banking sector are: *total liabilities, deposits and assets*. Moreover, Malmquist productivity index is used to measure the importance of technological change on the efficiency of banks between two periods.

Keywords: banking system efficiency, SFA, DEA, Malmquist index productivity, cost efficiency, technical efficiency.

Abstrakt

Sektori bankar përbën pjesën kryesore të sistemit financiar në vëndet në zhvillim. Për shkak të rëndesisë së lartë që ky sektor ka në ekonominë e vendit, duhet të bëhen analiza të vazhdueshme për të parë vijueshmërinë dhe ecurinë e efikasitetit të bankave. Kjo tezë ka si për qëllim të japë informacion në lidhje me efikasitetin e bankave që operojnë në Shqipëri gjatë periudhës 2006-2014. Studimet në këtë fushë ndjekin dy metoda të ndryshme për të matur efikasitetin e bankave: një metodë joparametrike (matodë matematikore) që quhet DEA(data envelopmen analysis)-analiza mbështjellëse e të dhënave dhe një metodë parametrike (metodë ekonometrike) që quhet SFA (stochastic frontier analysis) - analiza e kufirit stokastik. Studimet dhe kerkimet e mëparshme në sektorin bankar shqipëtar përdorin vetëm njërën nga metodat e lartëpërmendura. Ndërsa kjo tezë përdor të dy metodat: DEA dhe SFA dhe gjithashtu krahason rezultatet e cdo metode për të verifikuar se sa të qëndrueshme jane ato. Duke perdorur metodën DEA ne matëm eficencën teknike të bankave ndërsa me metodën SFA matëm eficencën technike dhe eficencën e kostos së bankave. Rezultatet tregojnë që sektori bankar në Shqipëri ka eficencën e kostos të ulët dhe eficencën teknike të lartë. Faktorët kryesorë që kanë një ndikim të rëndësishëm në efikasitetin bankar në Shqipëri janë: *totali i pasiveve, depozitat dhe asetet*. Për më tepër, indeksi prodhues Malmkuist (Malmquist productivity index) është përdorur për të matur rëndësinë e ndryshimeve teknologjike në efikasitetin e sistemit bankar midis dy viteve.

Fjalet Kyçe: efikasiteti i sistemit bankar, DEA, SFA, indeksi prodhues Malmkuist, eficenca e kostos, eficenca teknike.

Dedication

I dedicate this thesis to the most wonderful women of my world; to my admirable mom and to my lovely wife whose words of encouragement and push never were absent.

I would like to sincerely thank my advisor, Assist Prof. Dr. Urmat Ryskulov for his guidance, assistance and his valuable contribution in every step of this thesis.

Declaration Statement

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Epoka University or other institutions.

Eris Azizaj

June 2015

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List of Abbreviations

AAB	Albanian Association of Banks
BCC:	Model proposed by Banker, Charnes and Cooper at 1984
BoA:	Bank of Albania
CCR:	Model proposed by Charnes, Cooper and Rhodes
CRS:	Constant Return to Scale
DEA:	Data Envelopment Analysis
Dep	Deposits
DMU:	Decision Making Unit
EqCap	Equity Capital
EU:	European Union
GDP	Gross Domestic Product
i.i.d:	independently and identically distributed
IMF	International Monetary Fund
IS	Investments in Securities
NIRS:	Non-increasing Return to Scale
NP	Net Profit
NRBR	Number of branches
NREMP	Number of employees
PPF:	Production Possibility Frontier
PWB	Placement with banks
ROA	Return on Assets
RoAA	Return on Average Assets
RoAE	Return on Average Equity
ROE	Return on Equity
SFA:	Stochastic Frontier Analysis
SLAs:	Savings and Loan Associations
TA	Total Assets
TL	Total Loans
TLI	Total liabilities
VRS:	Variable Return to Scale

INTRODUCTION

The banking system efficiency and productivity has an important place in the developing countries since the banking system is the main component of the financial sector. Even though the banking system is the main element of financial institutions in Albania still a little is done to see its performance. Some of the reasons are the changes that are done through the years to establish an appropriate banking system and the inexistence of the data. For banks, efficiency implies an improved profitability, greater amounts of funds channeled through the system, better prices and service quality for consumers, and greater safety in terms of improved capital buffers in absorbing risk (Berger, Hunter, & Timme, 1993).

The information about the performance of banking system can be used from the banks manager to increase the operational efficiency of representative banks (or banking system) and also it can be used by the policymakers to set important regulatory to increase the performance of the banking system.

According to Stavarek and Poloucek (2004) the factors that have had significant effects on the efficiency and profitability of the banking sector in the countries in Central and Eastern Europe are: the creation of a two-level banking system based on the principles of the free market, the implementation of new methods and instruments for bank regulation and supervision, financial or bank crises, the large volume of subprime loans, the entering of foreign banks through the privatization process or the creation of branches or subsidiaries, the creation of new banks, the acquisitions and mergers at the level of the banking sector, the expansion of modern bank products and technologies.

The analysis of the efficiency of banks is important both from a microeconomic and a macroeconomic perspective (Berger & Mester, 1997). From a microeconomic perspective the efficiency of banks is important because of the increase of competition with the entering of foreign banks and the improvement of the institutional framework, of regulation and supervision (Filipaki, Margaritis, & Staikouras, 2009). From a macroeconomic perspective, the efficiency of the banking system influences the cost of financial intermediation and the stability of the entire financial system (Rossi, Schwaiger, & Winkler, 2005). Moreover, an improvement of the performance of banks indicates a better allocation of financial resources and thus an increase of the investments which favors the economic growth of that country.

The increasing number of studies related with the performance and efficiency of banks is a result of the dramatic changes that have occurred in the financial services sector and the very fast advancements that has happened in the financial and nonfinancial technologies (Berger & Mester, 2003). Valuation of the productivity of the banking system presents a major interest for public authorities because an increase in the productivity of banks can lead to better banking performance, decreased costs, and improvement in the quality of services, as well as to improvement in the allocation of resources and increased productivity of the entire economy (Andries, 2011). An increase in productivity of banks also has an important contribution to an increase in the soundness and stability of the banking system, providing that the achieved profits are channeled toward increasing equity and provisions that allow for better absorption of risks (Casu, Girardone, & Molyneux, 2004).

Albania took the status candidate for the EU on June 2014 and this is an important step for the countries which aim to be part of this Unity. However, a lot has to be done. One of them is the financial integration of the Albanian banking system. Moreover, the process of financial integration in the European banking industry is accompanied by the debate about the benefits of strengthened competition in credit markets and greater efficiency (Kooli, 2012). In this thesis it is aimed to measure the efficiency and productivity of Albanian banking system in order to see how ready is this banking system to compete within European banking industry. Studies related with the performance of banks mostly focus on frontier efficiency or X-efficiency, a concept that measures the performance deviations of some companies from the efficiency frontier, built based on best practices. The frontier efficiency measures how efficient the financial institution is, compared to the most efficient institution in the market. The frontier efficiency or the X-efficiency quantifies the cost efficiency of financial institutions with a greater precision than financial rates (DeYoung, 1997). Two different approaches will be used to investigate the factors that have an impact in the level of efficiency: a nonparametric approach (mathematical method), DEA-data envelopment analysis and a parametric approach (econometric method), SFA- stochastic frontier analysis. By using DEA it will be measured the technical efficiency of the Albanian banking system and SFA will be used to measure its cost and technical efficiency. Considering that the real level of efficiency of a financial institution is not known and that the opportunity of use a particular method is given by the distribution of the set of data, use of both methods will reduce the potential error caused by the distribution hypothesis of the data set (Berger & Humphrey, 1997).

Based on the last annual country reports of the IMF, Albania weathered the 2008 global crisis relatively well. However, the economy is weak, macroeconomic imbalances are large, and the financial sector faces several risks. Some of the risks that the Albanian banking system is facing are: Low bank profitability, rapidly rising nonperforming loans, systemic risk in the financial system which has increased with the recently established investment funds, high financial euroization, and a significant foreign bank presence. Even if the financial sector safety net and crisis preparedness and management frameworks are generally sound, still it is not expected a very good banking system efficiency.

The scientific innovation of the thesis comprised in two folds; the first fold is the theoretical section which comprises the deep literature review on banking sector in Albania and other countries, and the efficiency of banking sectors based on worldwide scholars.

Whereas, the second fold is the practical implementation of the analysis on the banking sector efficiency of the Albanian banking system.

This study is divided into three chapters. The first chapter shows the attempts and challenges of Albanian governments (time respectively) in order to establish a National bank with its own unified monetary system. Also, it describes shortly the history of banks in Albania from 1863 to 2013 and the rapid evolution and fast development that Albanian banking system has experienced through these years. The second chapter shows the studies done in the literature in the field. It summarizes shortly the methodology used and results found in different studies done by different authors in different countries. The third chapter describes the methodology that will be used in order to measure the banking system efficiency. The methods used are: DEA, Malmquist Index productivity and SFA. Moreover, this chapter compares the advantages and disadvantages of the DEA and SFA. Indeed, it shows the analysis part explaining the results from methods used and gives suggestions which variable data should be increased or decreased in order to improve the banking system efficiency.

CHAPTER ONE: BANKING SECTOR AND BANK EFFICIENCY

1.1.A short history of the Albanian banking system

To better understand the nowadays position of Bank of Albania and the banking system, it is necessary to know its past and the efforts done to establish it. The evolution of the Albanian banking system can be divided into 5 important phases which are closely related to each other, as a part of the creation and consolidation of the Albanian state.

Phase I (1863-1924): The first attempts to build a banking system in Albania was between the years 1863-1912 where in that time Albania was under the rule of Ottoman Empire[1]. The only bank operating during this time in Albania was the Ottoman Imperial Bank, which was founded on February 4, 1863 and the Turkish Agrarian Bank founded in 1888. However, during this period Albania did not have a real centralized bank and a unified monetary system of its own. After Albania declared its independence on November 28, 1912 one of the first steps taken, was the creation of Albanian central bank. The Ismail Qemali`s government signed an agreement with the representatives of the Italian and Austro-Hungarian banks to give them the opportunity to found the Central bank of Albania with a concession of 60 years. This central bank would be the only entity which was allowed to print money. After a short time this bank was closed because of the political climate in Europe. During the years of World War I, 1914-1918, many foreign countries set up their own banks to fund their military in Albania. However the activities of these banks were very limited as they served only as creditors.(Fishta, Periudha 1863-1924, 2003)

Phase II (1925-1939): In 1925 Ahmet Zogu came to power and again the main objective of his government was to found the Albanian National Bank. This time, not only the Italian banks but also the British government was interested to establish the Albanian

[1] http://www.bankofalbania.org/web/pub/Historiku_2266_1.pdf

National Bank under the agreement of a total control of economic concessions in Albania. However, Italians achieved to convince the British government retreated and let Italian banks make an agreement with the Albanian government. After that, the Italian banks offered the Albanian government a loan of 2 million gold francs in order to let them establish the Albanian National Bank. The agreement was signed on March 11, 1925. In 1936 for the first time the established bank created a unified currency for the nation called the Albanian Gold Franck. By the end of 1939 there were four banks operating in Albania with a combined total of 17 branches throughout the country. These banks were: The Albanian National Bank with 8 branches, Bank of Naples with 4 branches, The State Agrarian Bank with 4 branches and the Export Bank of Belgrade with 1 branch. The rest of the banks created up until this point ceased to exist (Fishta & Uruci, Periudha 1925-1944, 2003).

Phase III (1939-1944): During the World War II, Albania was occupied from different nations. Starting on April 7, 1939 Albania was occupied by Italy and the reign of Ahmet Zogu terminated. The Albanian banking system in that time faced many changes. During this period the main objective of banks operating in Albania was to control as much as possible the Albanian Banking Market. A harsh competition was between the two biggest banks: The Albanian National Bank and the Bank of Naples – Albania (established on November, 1937) which had become the two major players in the Albanian Banking System. The Albanian National Bank was leader in deposits of the political and military institutions established in Albania while Bank of Naples – Albania had the largest number of branches in country. In 1943 Italy retreated from the Albania and German troops takes over. They gave order to all the banks operating in country to freeze their activities. This order created a crisis in the Albanian Economy and paralyzed the entire banking system. All Italian banks retreaded from the Albanian Banking Market and the Albanian National Bank became the only operating bank in country. Moreover, its main function was to fund the German Army until November 29, 1944 when the Germans left. However, before they retreated, the German troops stole 9,634,690 Albanian Gold Francs[2] from the treasury of the National Bank. That time Albanian government requested from German government the gold reimbursement and deposition in a Swiss bank under the name of Albanian government, however they did not accepted and kept the gold in Berlin. (Fishta & Uruci, Periudha 1925-1944, 2003)

Phase IV (1944-1991): After the liberation of the country, the communist party with Enver Hoxha as its leader came to power. One of the steps taken was the establishment of a monetary system and foundation of a Bank of Albanian Government. The communist regime immediately started to take control on everything with a "private" status and it established a centralized economy where everything would be controlled by the government. The only bank which would operate in Albania was the Albanian National Bank with its new name Bank of the State of Albania and it would be operating under the control of Ministry of Finance. Since a lot of different banknotes were in circulation the government decided to unify the monetary system and the Bank of the State of Albania printed a new currency called LEK. All the other currencies would be exchanged and after a short period all the other currencies except LEK would be invalid in Albania. The Bank of the State of Albania was doing well and after some years it had to take the responsibility as the only legal entity to control all the financial aspects of the country. Throughout the years the Bank of State continued to help the government by playing the role of the creditor, giving out long term loans and by financing its new projects anytime the government requested. On August 1949 the Bank of State opened a smaller bank under its supervision called the Savings Bank. Its main function was to save the money of Albanian citizens. In this way, the Bank of State would deal only with government`s requests. The communist regime ideology was to

[2] See the book "Historia e Bankes Qendrore te Shqiperise", pp. 67

establish a country where all people are equal in all aspects of life based on Marxism-Leninism philosophy. The government started to create the Cooperatives in all rural regions in 1946 and later on it decided to create another bank which would be totally independent from the Bank of the State of Albania and had the responsibility to supervise and control all the financial aspects of Cooperatives. So, in order to separate the heavy industry and the agrarian production, in 1969 the government created the Agrarian Bank which would operate under the Ministry of Finance. Its main function was to administer all the financial needs and profits of the Cooperatives. There was not any competition between the two banks because they were two independent bodies from each other who served to the Albanian communist government. It is important to be mentioned that during this period for the first time in the history of the Albanian Banking system, all banks had Albanian capital and no foreign institution had control over the central bank. (Postoli, Balliu, & Striniqi, 2003)

Phase V (1991-present): In 1991 a new bank called the Albanian Bank of Commerce was established. The three new created banks throughout the years were all derived from the Bank of State and this was done in order to create a banking system which serves the communist ideology. In 1992 the communist regime fell and a new political and economical system came to power. The new democratic government transformed the economic system from a centralized one to a free market economy where everyone can have its private business and this made Albania a "market" opened to foreign investors. Moreover, the new government undertook reforms in the banking system by transforming it in a banking system with two levels: the Central Bank and the second level banks. The Bank of State was transformed in the highest bank in the country with its new name Bank of Albania. The Savings Bank, the Agrarian Bank and the National Commerce Bank, became second tier banks owned by the state. In 1992 the new established Bank of Albania became a member of IMF. During this period a lot of interested foreign and domestic companies opened their branches or new banks in Albania. One of the first banks entering the market was the Italian Albanian bank which started to operate in the capital (Tirana) in July 1993. After that it was the Dardania Bank which opened its doors to the banking market. And so on other banks such as United Bank of Albania (July 1994) and Tirana Bank (September 1996) was created. Up to year 1996 not everything in the banking system was doing well. The free market was not yet formed and stabilized and the private banks had a minimal influence in the economy when actually 90% of the banking deposits were controlled from state owned banks. During the year 1996 and the first months of 1997 some firms which offered high interest rates on deposits started to operate in the Albanian market. They achieved to have the attention of all social classes and most of the people started depositing their money in hopes of high returns. People put all their life savings and sold their property to have money and invest in these firms. These firms were pyramidal schemes and after a year they collapsed. Albanian banking system this time had the worst experience since its existence. The inflation rate went up to 40%. Every one lost their money in these schemes and moreover people lost their trust in banks. In order to better the created situation, the government achieved to attract foreign investments and the Bank of Albania blocked the assets that these pyramidal schemes had deposited at Bank of Albania. However as time passed the situation ameliorated and there were more investments coming in the country. Soon after new banks started to operate in Albanian banking market and day by day the economic environment was stabilizing. The following years are classified as the period of acquisition and privatization of banks because the Albanian banking system saw an enormous interest from foreign companies. The first bank which opens up for business in Albania was the Albanian American Bank (August 1997). In 1998, the National Commerce Bank was privatized and in 2000, the bank was sold out to a group of foreign investors (Ramaj, Gorishti, Kolasi, & Hysi, 2003). In 2006 more than 60% of the shares of the bank were sold to the Turkish group called Çalik-Seker

Konsorsiyum Yatirim A.S., which became the leading shareholder of the bank[3]. In 2004, the Raiffeisen International purchased 100% of the shares of the government owned Savings Bank for $129 million[4]. This was the first and biggest acquisition of its own in the Albanian banking history. Later on, in September 2007, it was announced the merger of the Italian-Albanian Bank with the American Bank of Albania[5]. Being two banks of the Italian Banks group called the Intesa SanPaolo group, they decided to share their assets and liabilities. Nowadays, they operate under the name IntesaSanPaolo Bank. Another Italian bank present in the banking system is the Veneto Banka. Also, Greek commercial banking companies could not be out of this circle. There are three banks among the system (Alpha Bank, National Bank of Greece, Tirana Bank) controlled by this group. In 2007 the French Societé General took control to the 75% of shares of the Popular Bank (Supervision Annual Report, 2007). Later on the Dutch group BFSE Holding BV bought 22.17% of the capital from Credins Bank[6]. The Emporiki Bank was one of the banks controlled by Greek commercial banking companies but in 2012 it was sold to CASA Group France[7], one of the most powerful banking groups in Europe and its name changed to Credit Agricole Bank Albania. First Investment Bank is the first bank totally Balkan owned capital and it operates under the Bulgarian First Investment Bank. Other banks with mixed capitals are Credit Bank of Albania, Union Bank, International Commercial Bank and United Bank of Albania. While Procredit Bank represent German shares according to the purchases done.

In Appendix (A) Figure 1, it is found the list of banks operating in 2013 with their percentage of shareholder`s equity, ownership and capital origin, respectively.

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[3] See Bank of Albania Annual Report 2006 pp. 30
[4] See Bank of Albania Annual Report 2004 pp. 14
[5] See Bank of Albania Annual Report 2007 pp.12 (a)
[6] See Bank of Albania Annual Report 2007 pp.12 (b)
[7] See Bank of Albania Annual Report 2012 pp.16

1.2. Banking Sector in Albania and its highlights for 2013

Nowadays Albanian banking system is healthy and it has seen a fast development through these years. Bank of Albania is the central bank and it has the responsibility to supervise the banking system in Albania. It is an independent legal institution which ensures the stability of the banking system and protects the interests of depositors and the general public. It also provides a sound banking system, whose activity is transparent and leads to an efficient market economy. Under its supervision (See Figure 2, Apendix A) are 16 commercial banks (second tier banks), 21 non-bank financial institutions, 333 foreign exchange bureaus, 2 unions of Saving and Loans Associations (SLAs), 121 SLAs and 1 representative office (Supervision Annual Report 2013). “The Albanian banking sector is concentrated and dominated by the foreign bank” (IMF country report: Albania, 2014). All the 16 second tier banks are private and mostly owned by foreign banks. According to the IMF Country Report on March 2014, the largest five banks in Albania hold about three-quarters of system assets and deposits until September 2013. Moreover, the subsidiaries of foreign banks (which include four of the top five banks, including from Austria, Greece, Italy, and Turkey) represent about 90 percent of total banking sector assets. According to Bank of Albania Supervision Annual Report of 2013, banking system assets represent over 90 percent of total financial system assets and the presence of the banking system in the economy measured by the ratio of total financial system assets over GDP is 91.13 percent. According to the Bank of Albania Supervision Annual Report, the banking system highlights during the year 2013 are:

1. The ratio of Total loans/ GDP of the banking system is 41.88%
2. Gross non-performing loans to outstanding loans ratio was at 23.5%.
3. Provisioning coverage continues to grow at notable rates, higher than non-performing loans. At end-2013, provisioning coverage ratio of non-performing loans stood at 65.2%

4. Annual deposits slowed down the growth pace compared to the same period a year earlier. During 2013, deposits grew by 3.4%, compared to 7.3% growth recorded during 2012;
5. Banking system's liquidity situation continues to be stable. Credit to deposits ratio dropped, standing at 55%. Liquidity indicator, though downward, continues to show satisfactory values, at 34.7%;
6. Market risks remain limited. As at end-2013, necessary capital to cover market risk shares only 3.9% of the banking system regulatory capital;
7. Capital adequacy ratio was above the regulatory minimum threshold of 12%, increasing to 17.9%, from 16.2% at end-2012;
8. Banking system's net profit was satisfactory at about ALL 6.6 billion at end-2013, from ALL 3.8 billion at end-2012;
9. RoAA and RoAE were positive, at 0.54% and 6.43%, improving markedly from a year earlier.

As at end-2013, banks conducted their activity through 529 branches/agencies operating within the territory of Albania, while one bank continues to operate with a branch abroad. These branches/agencies are located in almost the whole territory of Albania. The largest concentration of bank branches and agencies (40%)[8] continues to be in the capital (Tirana) which has also the largest concentration of population (27%)[9]. Meanwhile, banks continues to increase their activity through technological improvements to provide the electronic banking services of mobile banking and the new POS-Virtual and E-Commerce services to their clients.

[8] See Bank of Albania Annual Report 2013 pp.20 (a)
[9] See Bank of Albania Annual Report 2013 pp.20 (b)

CHAPTER TWO: LITERATURE REVIEW

The efficiency of banking institutions is an important factor that fosters the economic development in transition economies (Bonin & Wachtel, 2003). A lot of studies and researches are done in the field of literature. Most of them which study the bank efficiency in the developing countries that have undergone under a transition period focus at the impact of bank reforms, entrance of foreign banks and their effect on efficiency of the whole system, and privatization of state owned banks. Some of the studies summary`s are as follows:

In his study, Andries (2011) examined the determinants of the efficiency and productivity of the banking systems of seven central and east European (CEE) countries during a five year period, from 2004-2008. By using the stochastic frontier analysis and data envelopment analysis, the author showed that the average efficiency in CEE countries grew in the period analyzed. The improvement may be due to increased competition upon EU accession and the entry of foreign banks, as well as to extensive legislative changes that led banks to become more efficient.

Kraft and Tirtiroglu (1998) estimated X-efficiency and scale efficiency of old, new, state and private banks in Croatia. In this study, the author used the stochastic frontier analysis method to measure the banking system efficiency of the years 1994-1995. It was found that new established banks are more X-*inefficient* and more scale-*inefficient*, but more profitable than the older privatized banks and the state ones.

In another study done by Andries and Cocris (2010), it is analyzed the efficiency of the main banks in Romania, Czech Republic and Hungary for the period 2000-2006 by using DEA and SFA methods. It was found that the main banks of these countries have low levels of technical efficiency and cost efficiency. The main factors which had an impact in the efficiency were annual inflation rate, bank size, form of ownership, assets, reforms on banks and the interest rate liberalization.

Also Filipaki, Margaritis and Staikouras (2009) estimated the bank efficiency and productivity change across CEE countries and across banks with different ownership status for the period 1998-2003. The authors found that the productivity in the whole region initially declined, and then it saw an improvement due to further progress on institutions and structure reforms. Also, the foreign banks in this region are more efficient and productive than domestic private and state owned banks.

Grigorian and Manole (2002) in their research for the commercial banks efficiency in transition countries used the DEA method. One of the results found was that foreign ownership banks and restructuring of the enterprises enhance the efficiency of commercial banks.

Another research, done by Stavarek and Repkova (2012) in Czech banking industry; shows that largest banks perform significantly worse than mid-size and small banks. Authors use the well-known non-parametric approach DEA with models BCC and CCR. The results show that the gap between efficiency scores of the models BCC and CCR is huge (up to 70 percentage point). Also, it is found that the average efficiency in the banking sector remained nearly unchanged during the analyzed period (2001-2010) where each year is estimated separately. Moreover, it was seen a deterioration of average efficiency during the recent crisis period.

During the period 1993-1996 a series of reforms were implemented in banking system of the WAEMU (West African Economic Monetary Union) countries. A study was necessary to show the effect and improvement of the banking system. DEA and SFA methods were used to measure the technical efficiency and cost efficiency respectively. The results showed that local private banks are the most efficient ones, followed by foreign and then state owned banks. Even though some technological changes occurred through the period analyzed in the banking system, the Malmquist index productivity showed that the increase of technical efficiency is much more sensitive to the scale efficiency change than that of the incorporation of technological innovations. Also, it was found that variables like financial soundness, the ratio of bad loans per country, the banking concentration and the GDP per capita are important factors which has an impact in WAEMU banks efficiency (Kablan, 2007).

Thagunna and Poudel (2013) measured relative efficiency and potential improvement capabilities of Nepali banks by scrutinizing intermediation aspects. By using Data Envelopment Analysis method it was found that efficiency level is relatively stable and has increased on overall. Moreover, it was found no efficiency relationship between level and ownership structure of banks and also, there were no notable differences in the efficiency levels of banks according to their asset size.

Fries and Taci (2005) studied the cost efficiency of 289 banks in 15 east (post communist) European countries of the period 1994-2001. The results showed that there is no relationship between a country's progress in banking reform and cost efficiency and that banking systems in which foreign-owned banks have a larger share of total assets have lower costs. Also, it was seen that private banks are more efficient than state-owned banks. Moreover, privatized banks with majority foreign ownership are the most efficient, followed by newly established private banks, both domestic and foreign-owned and those with majority domestic ownership are the least efficient private banks.

Fang, Hasan and Marton (2011) studied the cost and profit efficiency of 171 commercial banks in six South-Eastern European countries (one of them was Albania), during the period 1998-2008. It was shown that the average profit efficiency is 53.87% and the average cost efficiency is 68.59%. The regression results showed that ownership structure had a significantly impact on efficiency. It was found that foreign majority ownership banks had higher profit efficiency and lower cost efficiency. Compared to domestic private banks government owned banks had lower profit efficiency but compared to cost efficiency no difference was seen. Moreover, the findings showed that over time, foreign banks become more cost efficient but less profit efficient than domestic private banks and also government-owned banks become more profitable than domestic private banks in the later years of the transition.

Ariss (2010) investigated the impact of different degrees of market power to the cost and profit efficiency levels and overall bank stability across developing economies. The results show that an increase in the degree of market power leads to greater bank stability and enhanced profit efficiency, despite significant cost efficiency losses. Albanian banking system was part of this study and it was found that it has an average cost efficiency and low profit efficiency compared to other Central and Eastern European countries.

As it is seen from the above research studies, it is concluded that there is no clear "formula" whether the foreign owned banks are more efficient than domestic owned banks (or vice versa) or that state-owned banks are less efficient than domestic private banks. It is concluded that there are other factors different from that of ownership structure that determines the efficiency of banks. While some studies conclude that banks with majority foreign ownership are the most efficient banks (Bonin, Hasan, & Wachtel, 2005 a) (Bonin, Hasan, & Wachtel, 2005b); (Hasan & Marton, 2003);(Kasman & Yildirim, 2006); (Kraft, Hofler, & Payne, 2006); (Mertens & Urga, 2001); (Weill, 2003); (Grigorian & Manole, 2002); (Jemric & Vujcic, 2002); (Fries & Taci, 2004); (Filipaki, Margaritis, & Staikouras, 2009); (Fang, Hasan, & Marton, 2011) there are other evidences from the literature that shows that domestic private banks or state owned banks are the most efficient banks in the system (Berger, DeYoung, Genay, & Udell, 2001); (Green, Murinde, & Nikolov, 2003); (Lensink, Meesters, & Naaborg, 2008); (Vennet, 1996); (Zajc, 2006);(Kablan, 2007); (Kraft, Hofler, & Payne, 2006). Based on the literate on the field it can be concluded that the efficiency of banks depends on the settings and policies of each bank itself and the policies of the country.

Another important factor that enhanced the efficiency of banks in transition economies is the EU accession. Brissimis, Delis and Papanikolaou (2008) studied the efficiency of ten newly acceded EU countries. It was found that banking reforms and competition exerted a positive impact on profit efficiency. “The governments, with financial and strategic support from international organizations, spent enormous amounts of effort to develop a competitive and efficient banking system, based on market principles, for the transformation from central planning to market economies and for converging toward the criteria for European integration” pp. 125 (Yildirim & Philippatos, 2007)

Studies and research on the efficiency and productivity of the Albanian banking system are a few. The research conducted by Kristo (2014) measures the Albanian bank system efficiency as a whole and of some banks for the period 2002-2011. By using the traditional method, the author found a poor performance and decreased efficiency of the Albania banking system after year 2007, and with the SFA method it was found that in particular, the largest bank seems to be more efficient than the smaller banks. However, Barbullushi (2010) by using the traditional method and the DEA method for the period 2005-2010 found that smaller banks are more competitive and efficient than bigger banks (in the context of internal financial system).

In another research Kristo and Gruda (2010), investigated the interrelationships among bank competition, efficiency and stability in Albanian banking system for the period 1999-2009. It was found that Albania had an increase in banking competition which had a positive impact in efficiency of banks. However, after a while a further addition of the level of competition was associated with an increase in fragility of the banking system and a decrease in the bank efficiency.

Different from other studies, Kalluci (2011) analyses net interest margin as a measure of efficiency for the banks which operate in Albanian banking system during the period 2002-2007. According to the estimations carried out for the Albanian banking system, the results show that the net interest margin is positively affected by the interest rate volatility, by the level of operating expenses which have had an increasing tendency and by the amount of banks' reserves in the Central Bank. Other factors that affect the net interest margin are the level of bank capitalization, net commission incomes which are negatively related to the dependent variable implying that these two indicators are substitutes of each-other; the effectiveness of management work; credit risk and the concentration level in terms of loans.

Gremi (2013) studied the internal factors affecting Albanian banking profitability for 12 commercial banks during the period 2005-2012. Using regression analysis fixed effect model it was found that banks with greater size of total assets, loans, deposits and net interests have higher profitability than other banks.

CHAPTER THREE: DATA, METHODOLOGY AND ANALYSIS

3.1. Data Description

All data in this study are taken from Albanian Association of Banks, Bank of Albania Supervision Annual Reports (2006-2013), IMF 2013 country report and The Institute of Statistics (INSTAT).

- As input we have chosen *total loans (TL)*, *total liabilities(TLI)*, *number of employees (NREMP)*, *number of branches/agencies (NRBR)*, (all inputs mention above are in million LEK), and
- As output it is chosen *total assets (TA)*, *deposits(Dep)*, *equity capital(EqCap)*, *net profit(NP)*, *return on assets(ROA) and return on equity(ROE).*
- *Investments in securities(IS)* and *placement with banks(PWB)* have been used as intermediate.
- *B1* represent the annual data of the Bank1, *B2* represents the data of Bank2, …, *BoA11* represents the data of Bank11. All these 11 banks represent around 87.8% of total assets of the banking sector for year 2014(Albanian Association of Banks, Quarterly Reports for 2014).

3.2. Methodology

In the literature in the field the most widely used methods to measure the bank system efficiency in the transition economies are the DEA and SFA. Below it is found a short review about these two methods that will be used in this thesis to measure the efficiency of the banks.

In order to allow the comparison of the DEA and SFA results it will be used the same inputs and outputs. As output we will select the variables that we want to increase and as input it will be chosen the variables that we want to decrease. However some variables may change from the point of view; that is, for someone a variable may be an input and for someone else it may be an output. For example, the number of employs in a bank is an output for the manager of that bank and an input for the owner of that bank.

In the analysis of the efficiency of the banking system in Albania it will be used: a parametric method – the SFA Method (Stochastic Frontier Analysis) and a nonparametric method – the DEA Method (Data Envelopment Analysis). The use of two different methods is done because of three important reasons:

1. Although in many studies related with the efficiency and productivity a hierarchy of methods was tried, until now no consensus is reached to set which method should be used (Bauer, Berger, & Ferrier, 1998).
2. The use of different methods for the analysis of an economic phenomenon is a cross-verification method for the robustness of the obtained results (Leamer & Leonard, 1983).
3. Considering that the real level of efficiency of a financial institution is not known and that the opportunity for using a certain method is given by the distribution of the set of data, the use of both methods will reduce the potential error caused by the data set distribution hypothesis (Berger & Humphrey, 1997).

The two methods used present both comparative advantages and disadvantages:

- The DEA method is a determinist method based on linear programming which does not take into account the random errors and thus does not require predefinition of the distribution of the error term (or predefinition of the functional form). While the SFA Method is a stochastic method, which integrates random errors but also requires predefinition of the functional form.
- In the case of the SFA method, the output of a company is a function of inputs, inefficient and random error and it requires predefinition of the error term distribution. The DEA method does not take into account the statistic noise; as such

the estimations regarding efficiency can be biased if the production process of the company is characterized by stochastic elements.

- Because of its determinist character, the DEA method assumes as hypothesis that all efficiency deviations are caused by the company. Nevertheless, there are some elements such as the legislative framework, level of competition, constraints in finance etc. which cannot be controlled by the company and which affect the performance of the company. On the contrary, the SFA method allows for the modeling of these factors by introducing the random error in the specification of the determining model for the frontier efficiency (Murillo-Zamorano, 2004).

3.2.1. DEA-Method

Data envelopment analysis (DEA) is a non-parametric method in decision science and economics which is used to measure the production frontiers. In economics, a production frontier or production possibility frontier (PPF) is a curve which indicates the maximum level of outputs that can be produced from some inputs. DEA use linear programming to measure the productive efficiency of a Decision Making Unit (hereafter DMU). It provides an efficiency frontier for all analyzed units and after that; it selects these units with the best performance that are in the efficiency frontier as efficient units. The other units that are below the curve are considered as inefficient units and an inefficiency score is associated to them. A unit that is selected as inefficient means that another unit with the same amount of inputs produces higher outputs or the same amount of outputs is produced by less quantity of inputs. The level of the efficiency of a DMU maximum can be equal to 1.

DEA method maximizes the relative efficiency of each DMU and assumes that all the averages of each DMU can be achieved by each DMU of the data set. In this way the efficient and inefficient units are identified. Moreover DEA method suggests which inputs should be taken under consideration in order to increase the efficiency of the units which are considered as inefficient.

There are two different orientation models of DEA: the input-oriented model and the output-oriented model. Input-oriented model keeps outputs constant and try to minimize the inputs in order to give the same amount of outputs. While the output-oriented model keeps the inputs in the same level and tries to maximize the possibility level of outputs.

Evaluating the efficiency of a DMU by DEA, various assumptions related with the economy of scale are made: CRS-constant return to scale, VRS-variable return to scale or NIRS-non increasing return to scale.

DEA method initially was introduced in 1957 by Farell. Since then, hundreds of articles have been published and a lot of models have been found. The most important and useful ones are CCR, BCC and SBM models. In this thesis it will be used the CCR model (a model proposed by Charnes, Cooper and Rhodes at 1978) an input-oriented model which is based on the Constant Return to Scale (CRS) and the BCC model (a model proposed by Banker, Charnes and Cooper at 1984) an output-oriented model which is based on the Variable Return to Scale (VRS). We will measure the technical efficiency of the banking system through years. Technical efficiency focuses at the level of inputs or outputs. Being technically efficient for a DMU means to minimize its inputs at a given level of outputs, or maximize its outputs at a given level of inputs. The CRS model does not differentiate the pure technical efficiency from the non constant return to scale effects while VRS decompose the general technical efficiency (i.e efficiency measured by CRS model) into local pure efficiency and a scale efficiency factor.

Assume that we want to measure the technical efficiency of *n* DMUs. Each DMU use *m* different inputs to produce *k* different outputs. Specifically, $\boldsymbol{DMU_j}$ uses amount x_{ij} of input *i* and produces amount y_{rj} of output *r*. We assume that $x_{ij} \geq 0$ and $y_{rj} \geq 0$ and further assume that each DMU has at least one positive input and one positive output value.

Charnes, Cooper and Rhodes (1978) modified DEA by introducing a new model which focuses on the allocation of different averages of inputs and outputs for each DMU. The solution of the following problem gives us the efficiency of each DMU:

$$\max w_0 = \frac{\sum_r u_r y_{rj_0}}{\sum_i v_i x_{ij_0}} \text{ subject to:}$$

$$\frac{\sum_r u_r y_{rj_0}}{\sum_i v_i x_{ij_0}} \leq 1 \text{ for each } j = 1,2,\ldots,n$$

$u_r, v_i \geq 0$, $r = 1, 2, \ldots, k$; $i = 1, 2, \ldots, m$

Where:

w_0 - relative efficiency,
u_r -weight of output *r*
v_i - weight of input *i*
x - input vector
y - output vector
n – number of banks
m – number of inputs
k – number of outputs

The problem is that the model function described above is partially linear, however we want it to be fully linear. Our model maximizes the numerator and minimizes the denominator; however it has an infinite solution. To deal with this we will set a new restriction which is $\sum_i v_i x_{ij_0} = 1$

By introducing this restriction the model becomes

$$\max w_0 = \sum_r u_r y_{rj_0} \text{ subject to:}$$

$$\sum_i v_i x_{ij_0} = 1$$

$\sum_r u_r y_{rj} - \sum_i v_i x_{ij} \le 0$ for j=1,…n

$u_r, v_i \ge 0$, r = 1, 2, …, k; i = 1, 2, …, m

The additional restriction $\sum_i v_i x_{ij_0} = 1$ means that the sum of all inputs is established to be equal to 1. By keeping inputs as constant the restriction seeks the solution that ensures the maximum value for outputs.

Generally, in linear programming problems the more restrictions we put the more difficult is to solve that problem. Using the same data we can build the dual program for any linear program and moreover the initial program and the dual program will have the same solution identically. Usage of the dual program in DEA model will reduce the number of restrictions and the main problem can be written as:

$\theta_j = \min \theta$, and $\max \sum_{i=1}^{m} s_{\bar{i}} + \sum_{r=1}^{k} s_{\hat{r}}$ subject to:

$\theta_j x_{ij} - s_{\bar{i}} - \sum_j x_{ij} \lambda_j = 0$, for i= 1, 2,…,m

$\sum_j y_{rj} \lambda_j - s_{\hat{r}} = y_{rj_0}$, for r = 1,…,k

$s_{\bar{i}}, s_{\hat{r}}, \lambda_j \ge 0, \; j = 1, 2, ..., n$

Where:

θ_j - efficiency of the DMU_j

y_{rj} - the amount of r^th output produced by DMU_j using x_{ij} amount of i^th input

$s_{\bar{i}}$ - input slack

$s_{\hat{r}}$ -output slack

Note that the choices of $s_{\bar{i}}$ and $s_{\hat{r}}$ do not affect the optimum solution θ_j. The DMUs with level of efficiency $\theta_j = 1$ are classified as efficient and the other ones with efficiency $\theta_j < 1$ as inefficient.

If we add the restriction $\sum \lambda = 1$ (convexity condition) then the CCR model is converted to BCC model and it is expressed as:

$$\min z_0 = \theta_j - \varepsilon \sum_{i=1} s_{\bar{i}} - \varepsilon \sum_{r=1}^{k} s_{\hat{r}} \text{ subject to:}$$

$$\theta x_{ij} = s_{\bar{i}} + \sum_j x_{ij} \lambda_j \text{ for } i = 1,2,\ldots,m$$

$$y_{rj_0} = -s_{\hat{r}} + \sum_j y_{rj} \lambda_j \text{ for } r = 1,2,\ldots,k$$

where: $\sum \lambda = 1,\ s_{\bar{i}}, s_{\hat{r}}, \lambda_j \geq 0\ \ j = 1,2,\ldots,n$

The BCC-efficiency scores are obtained by running the above model for each DMU.

3.2.2. The Malmquist Productivity Index

The Malmquist Productivity index firstly introduced by Caves et al. (1982) will be used to estimate the efficiency change and the technological modification between time *t* and *s = t+1* of each DMU. Following Fare et al. (1992) the output-based Malmquist productivity index between time periods t and (t + 1) can be decomposed into two components (technical efficiency and technological change) and is expressed as follows:

$$M_{t,t+1}(y^t, y^{t+1}, x^t, x^{t+1}) = \underbrace{\frac{D^{t+1}(y^{t+1}, x^{t+1})}{D^t(y^t, x^t)}}_{Eff} \underbrace{\left[\frac{D^t(y^t, x^t)}{D^{t+1}(y^t, x^t)} \times \frac{D^t(y^{t+1}, x^{t+1})}{D^{t+1}(y^{t+1}, x^{t+1})} \right]^{1/2}}_{TechgclEff}$$

$$Totalproductivity\ change = Efficiency\ change \times Frontier\ shift$$

where

- $M_{t,t+1}(y^t, y^{t+1}, x^t, x^{t+1})$ represents the Malmquist productivity index
- $D^t(y^{t+1}, x^{t+1})$ represents the distance function from the point observed in the period t+1 to the frontier technology of period t.
- Eff is a ratio which measures the change in the output-oriented measure of the Farell technical efficiency between period t and t+1.
- $TechgclEff$ measures the technological improvements between the periods in x^{t+1} and x^t
- x^t and y^t are the input and output vectors in period *t* respectively

If the value of M is greater than 1(i.e M>1) this means that productivity of the DMU is growing, if M<1 the productivity decline and if M=1 productivity is in a stagnation period. If the value of the term *Eff* >1 than this means that DMU is moving closer to the production frontier, if *Eff* <1 the DMU is diverging from production frontier and if *Eff* =1 the distance from production frontier is unchanged. If the square root term *TechgclEff* is greater than one (i.e *TechgclEff>1*), less than one i.e *TechgclEff < 1* and *TechgclEff =1* this means that technological modification is improving, deteriorating and unchanged respectively.

In this study the Malmquist index is estimated by using MaxDEA type linear programming method. We will calculate four different distance functions: $D^t(y^t, x^t)$, $D^t(y^{t+1}, x^{t+1})$, $D^{t+1}(y^t, x^t)$ and $D^{t+1}(y^{t+1}, x^{t+1})$ in order to construct the Malmquist index for adjacent periods. Assuming that the technologies have constant return to scale the four DEA linear programs for the DMU *i*, where *i=1,2,…,N* are as follows:

$$\begin{aligned}
&\left[D^t(y^t, x^t)\right]^{-1} = \max_{\phi,\lambda} \phi \\
&s.th \\
&-\phi y^t + Y^t\lambda \geq 0 \\
&x^t - X^t\lambda \geq 0 \\
&\lambda \geq 0
\end{aligned}$$

$$\begin{aligned}
&\left[D^t(y^{t+1}, x^{t+1})\right]^{-1} = \max_{\phi,\lambda} \phi \\
&s.th \\
&-\phi y^{t+1} + Y^t\lambda \geq 0 \\
&x^{t+1} - X^t\lambda \geq 0 \\
&\lambda \geq 0
\end{aligned}$$

$$\begin{aligned}
&\left[D^{t+1}(y^{t+1}, x^{t+1})\right]^{-1} = \max_{\phi,\lambda} \phi \\
&s.th \\
&-\phi y^{t+1} + Y^{t+1}\lambda \geq 0 \\
&x^{t+1} - X^{t+1}\lambda \geq 0 \\
&\lambda \geq 0
\end{aligned}$$

$$\begin{aligned}
&\left[D^{t+1}(y^t, x^t)\right]^{-1} = \max_{\phi,\lambda} \phi \\
&s.th \\
&-\phi y^t + Y^{t+1}\lambda \geq 0 \\
&x^t - X^{t+1}\lambda \geq 0 \\
&\lambda \geq 0
\end{aligned}$$

where;

- y^t and x^t are the output and input vectors at time t
- λ is a solution value of weight
- $1 \leq \phi < \infty$ is the proportional increase in outputs that could be achieved by the firm, with input quantities held constant.
- $0 < \frac{1}{\phi} = \delta \leq 1$ defines the technical efficiency
- $(X\lambda; Y\lambda)$ is the projected point on the surface of this technology produced by the radial expansion of the output vector.

We will use the MaxDEA Pro 6.4 version software program to estimate the level of technical efficiency of DMUs through the DEA method.

Technical efficiency analysis measured by DEA method will help us to answer the following questions: As financial intermediaries, what banks in Albania produce? Do they use the appropriate quantities of inputs to produce the required quantities of outputs? Which inputs (outputs) should be used (produced) less or more to increase the efficiency of banks?

3.2.3. SFA-Method

The SFA method is an econometric and deterministic method which estimates the efficiency frontier. It was first proposed by Aigner, Lovell and Schmidt (1977) and by Meeusen and van den Broeck (1977). It uses a functional form to determine the relationship between inputs and outputs of a specific DMU. An advantage of the SFA is that different from DEA, it separates the inefficiency term from the residual while, DEA assumes that all efficiency deviations are caused by the DMU itself. Moreover, SFA method allows for the modeling of some factors that even though they are not controllable by the DMU itself, they have an impact in the performance of that DMU. Some of these factors may be level of competition, legislative framework, etc. The SFA models these kinds of factors by introducing the random error in the specification of the determining model for the frontier efficiency (Murillo-Zamorano, 2004).

The most important reasons why SFA method is chosen as one of the methods to be used in this thesis is that in Albanian banking system (as in other transition economies) the quality of data set is not perfect and measurement errors are widespread. Fries and Taci (2005) suggest the parametric methods for analyzing bank efficiency because they have more appropriate empirical tools and are more robust to data problems. Moreover, the SFA method estimates the efficiency frontier of a DMU with a composite error term which it is composed by the nonnegative efficiency and the noise part.

The most widely used and known models of SFA models are *Cobb-Dauglas, Translog*, and *Fourier* functions.

The **Cobb–Douglas production function** is a particular functional form of the production function, widely used to represent the technological relationship between the amounts of two or more inputs, particularly physical capital and labor, and the amount of output that can be produced by those inputs (Douglas, 1976).

The **Translog** or **transcendental logarithm function** is a more generalized model of Cobb-Douglas. It allows the flexibility of restrictions related with the stochastic frontier function. Indeed, when the Translog function is applied, the data indicates its real value of the curvature of the function rather than imposing prior hypothesis regarding to its value.

Fourier function is less used in the literature in the field because generally it does not give good approximation.

Taking under consideration the variety of the functions that banks in Albania have, in this thesis it will be estimated the cost efficiency and technical efficiency of these banks under Cobb-Douglas model.

The deterministic production frontier is given by the following function:

$$y_i = f(x_i, \beta) \times TE_i$$

where; $TE_i = \exp\{-u_i\}$ is the technical efficiency of i^th^ DMU and $0 < TE_i \le 1$; $u_i \ge 0$

y_i - the outputs of i^{th} DMU

x_i - a vector of M inputs of the i^{th} DMU

β - the input elasticity (a vector of technology parameters to be estimated)

If $TE_i = 1$ this means that the i^{th} DMU is efficient, if $TE_i < 1$ then ith DMU is inefficient telling us that some inputs are misused or overused.

However in this case the producer's specific random errors which are not controllable by the producer itself are ignored. To incorporate the fact that output can be affected by random errors into the analysis, we have to specify the stochastic production frontier

$$y_i = f(x_i, \beta) \times \exp(v_i) \times TE_i$$

where; $TE_i = \exp\{-u_i\}$ is the technical efficiency of i^{th} DMU and $u_i \ge 0$

y_i - the outputs of i^{th} DMU

x_i - a vector of M inputs of the i^{th} DMU

$f(x_i, \beta)$ - is a deterministic part common to all DMU

$\exp(v_i)$ - is the specific random error for DMU_i

If the above function is written in the Translog form we have:

$$\ln y_i = \ln f(x_i, \beta) + v_i - u_i$$

or

$$\ln y_i = \beta_0 + \sum_n \beta_n \ln x_{ni} + v_i - u_i$$

where; $f(x_i, \beta)$ - the production function

u_i -technical inefficiency and $u_i \geq 0$

v_i - the random error (statistical "noise")

β - the input elasticity

y_i - the outputs of i^th^ DMU

x_i - a vector of M inputs of the i^th^ DMU

The v_i variable estimate the error term of each specific DMU_i and it is assumed to have a normal (or symmetric) distribution, in particular they are independently and identically distributed (hereafter i.i.d) as $N(0,\sigma_v^2)$ while u_i variable is manageable by DMU_i and is assumed to have a semi-normal distribution $N^+(0,\sigma_u^2)$.

In the above functions the u_i variable is assumed to be stable over time and this is difficult to be accepted because the managers of each DMU will learn from past experiences in the production function in order to change the effects of efficiency over time.

Related with this problem, Battese and Coelli (1992) suggest the following model for the unbalanced panel data (such as in our case) in which the terms which estimates the u_i variable vary exponentially over time;

$$y_{it} = f(x_{it}, \beta) \times \exp(v_{it} - u_{it})$$

and

$$u_{it} = \eta_{it} \cdot u_i = u_i \cdot \exp\left[-\eta(t-T)\right] \text{ where } t=1,2,3,\ldots,T$$

Where; η is the unknown scalar parameter

u_i \`s are assumed to be i.i.d nonnegative truncations of $N(\mu,\sigma^2)$ distribution

v_{it} \`s are assumed to be i.i.d $N(0,\sigma^2)$

Batesse and Coelli (1992), mention that the statistical noises vary among banks and through years. The production frontier variable over time can be expressed in translog form as follows:

$$\ln y_{it} = \beta_0 + \sum_n \beta_n \ln x_{nit} + \beta_t t + \frac{1}{2}\sum_n \sum_k \beta_{nk} \ln x_{nit} \ln x_{kit} + \frac{1}{2}\beta_{it} t^2 + \sum_n \ln x_{nit} t + v_{it} - u_{it}$$

where y_{it} - is the output vector

x_{it} - is the input vector

β - is the independent variable coefficient

v_{it} - is the random error $N(0, \delta_v^{\ 2})$

u_{it} - is the error variable and it follows a normal truncated distribution

t – is the time component

The generalized form of the Translog function with m inputs can be model as follows:

$$\ln(Y) = \ln A_{\alpha_i, \beta_{ij}} + \sum_{i=1}^{m} a_i \cdot \ln X_i + \frac{1}{2} \cdot \sum_{i=1}^{m} \sum_{j=1}^{m} \beta_{ij} \cdot \ln X_i \cdot \ln X_j$$

In a Translog production function, the marginal product is $(\frac{\partial Y}{\partial X_j}) = \alpha_i + \sum_{j=1}^{m} \beta_{ij} \cdot \ln X_j$

Moreover the marginal product of a Translog production function expressed above is the Cobb-Douglas production function. In order to estimate the parameters with the current assumption of a normal truncated distribution for the inefficiency term, the maximum likelihood method will be used. Moreover, to measure the efficiency scores it will be used the Battese and Coelli`s (1992) time-varying stochastic frontier approach for panel data with firm effects.

3.3. Analysis and Results

The section is dedicated to the results of the DEA Frontier and Stochastic Frontier Analysis. The DEA Frontier analysis contains the CCR, BCC model, and Malmquist Index Productivity. While the stochastic frontier analysis includes the Cobb Douglass cost function and production function by using the independent variables namely; assets, deposits and equity capital separately.

3.3.1. BCC, CCR Models and Malmquist Index Productivity

The results of the BCC model analysis shows that the banking sector is efficient based on the geometric mean of efficiency (See: Table 1). However, these efficiency scores of the banks for some years are below the efficiency score of 1, indicating that banks in these years were not able to show necessary efficiency on its operations. For instance the Bank3, Bank4, Bank5 and Bank10 are with an efficiency score of 1 for all years while Bank1 (B1) scores 0.986 in year 2011, Bank2 (B2) 0.99 in 2008 and 0.992 in 2014 and so on. In addition, it can be said that the most efficient year for the banks in Albania was the year 2006 where only bank (B9) had an efficiency score of 0.979. Moreover, the least efficient bank for the year 2007 is Bank6 with score of 0.957, for the year 2008 the Bank6, for the year 2009 is Bank9, for 2010 is Bank11, for 2011 is Bank6, for 2012 is Bank6, for 2013 is Bank9, and for the year 2014 is Bank11.

Also an important part of DEA model is that it shows the quantity of inputs (outputs) the DMU should decrease (increase) in order to be efficient. The ideal inputs (outputs), project data and the original value of data have the following relation:

Target value = original value + radial movement + slack movement

See Appendix B (Projection, Slack and Radial movements of BCC and CCR), for the target values (i.e projection) of each variable of each particular bank and for each particular method. Table 27 and Table 28 (See Appendix B) tells the managers of the inefficient banks the necessary variables that they should take into consideration in order to reach the efficient level. For instance, in 2006 Bank9 is the only inefficient bank and it has to increase the output *TA* by 598mln, *Dep* by 546mln, EC by 32mln, NP by 1mln in radial movement to reach the mean efficiency in the sector, while to reach more efficient position or to be in efficient frontier line the bank could use 13 number of outlets less, EC for 566mln more, NP for 360 more, ROA for 0.01 more and ROE for 0.16 more in order to sustain the output efficiency frontier. For other banks refer to Appendix B, BCC-Model.

Table 1: Efficiency of Banks from 2006-2014 BCC-model

DMU	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	GM
Efficiency (2006)	1	1	1	1	1	1	1	1	0.979	1	1	0.998
Efficiency (2007)	1	1	1	1	1	0.957	0.996	1	0.997	1	1	0.995
Efficiency (2008)	1	0.990	1	1	1	0.951	1	1	0.987	1	1	0.993
Efficiency (2009)	1	1	1	1	1	1	0.961	1	0.909	1	0.999	0.988
Efficiency (2010)	1	1	1	1	1	1	1	1	0.898	1	0.883	0.979
Efficiency (2011)	0.986	1	1	1	1	0.883	1	1	0.887	1	0.951	0.972
Efficiency (2012)	1	1	1	1	1	0.956	1	1	1	1	1	0.996
Efficiency (2013)	1	1	1	1	1	1	0.954	1	0.871	1	1	0.983
Efficiency (2014)	1	0.992	1	1	1	0.980	1	1	1	1	0.952	0.993
Efficiency(t): GM	0.998	0.998	1	1	1	0.969	0.990	1	0.946	1	0.975	0.989

Apparently, from BCC model the results of the CCR model (See: Table 2) shows that the banking sector based on the geometric mean score of an efficiency appears to be less efficient than the BCC model. Based on the CCR model the efficiency of Bank10 loses its efficiency for the years from 2006 to 2008, which was evaluated as an efficient bank according to the BCC model. So, the efficient banks according to CCR model are B3, B4 and B5. B9 seems to be the less efficient bank of all banks during the period analyzed. The year 2012 appears to be an efficient year for all banks except the Bank6. The difference between the geometric mean score efficiencies is due to the fact that CCR model does not consider some factors which might have an indirect impact on the technical efficiency. Thus, it can be said that there are more factors which might have impact on the technical efficiency for the Bank10. Moreover, considering the inputs to produce an output the Bank10 could use more optimal input to produce maximum output. What is the most important issue is that all the efficient banks are private and have a foreign capital based on companies and individuals on other countries.

Following from the yearly efficiency score of the banks, the analysis results shows us the efficiency scores of each bank compared to the previous and next years (See: Table 3) respectively.

Table 2: Efficiency of Banks from 2006-2014 CCR-model

DMU	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	GM
Efficiency (2006)	1	1	1	1	1	1	1	1	0.972	0.968	1	0.995
Efficiency (2007)	1	1	1	1	1	0.928	0.947	1	0.985	0.976	1	0.985
Efficiency (2008)	1	0.954	1	1	1	0.939	0.955	1	0.916	0.981	0.997	0.976
Efficiency (2009)	1	1	1	1	1	0.994	0.952	1	0.887	1	0.952	0.980
Efficiency (2010)	1	1	1	1	1	1	0.975	1	0.898	1	0.852	0.974
Efficiency (2011)	0.973	1	1	1	1	0.873	1	1	0.884	1	0.931	0.968
Efficiency (2012)	1	1	1	1	1	0.945	1	1	1	1	1	0.995
Efficiency (2013)	1	1	1	1	1	0.935	0.951	1	0.871	1	1	0.977
Efficiency (2014)	1	0.991	1	1	1	0.853	1	1	0.903	1	0.890	0.965
Efficiency(t): GM	0.997	0.994	1	1	1	0.939	0.975	1	0.923	0.992	0.956	0.979

Efficiency (t-1) = the efficiency score of period t referring to the technology of period t-1

Efficiency (t+1) = the efficiency score of period t referring to the technology of period t+1

Table 3 represents the efficiency score of 1 as a benchmark, indicating the banks which scored efficiency score less than 1 performed inefficiently compared to the previous year (t-1) and next year (t+1) of the particular banks. The efficiency score greater than 1 indicates how well the bank performed compared to the previous and the next year, considering the efficiency score of current year with the technology of previous year for t-1, and the efficiency score of current year referred to the technology of next year for t+1. Thus, it can be said that in 2007 the least efficient bank in Albanian banking sector is Bank6 with an efficiency score of 0.976 compared to the year of 2006, whereas, the most efficient bank for the year 2007 is Bank4 with an efficiency score of 2.245 compared to the year 2006. Moreover, it can be said that on average for the period 2006-2014 the Bank11 is less efficient with an efficiency score of 0.995 and Bank4 is most efficient bank for t-1, while for the case of t+1 the least efficient bank is Bank9 and the most efficient one is Bank4. The most interesting results on Table 3 are the Bank3 efficiency scores equally to 1 for all years. This indicates that this bank has been using stable technology during these years and also it has been a “benchmark” for the period analyzed. Moreover, B4 has the largest efficiency score at 2008 by experiencing a boom in technological efficiency referring to the year 2007.

Table 3: Efficiencies of Banks compared to t-1 and t+1 year. BCC-model

DMU	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	GM
Efficiency (2007-1)	1.087	1.583	1	2.245	1.395	0.976	1.108	1.420	1.192	1.697	1.074	1.300
Efficiency (2008-1)	1.266	1.245	1	8.808	1.287	0.970	1.045	1.324	0.996	1.321	0.992	1.368
Efficiency (2009-1)	0.985	1.004	1	1.014	1.225	1.159	0.964	1.406	0.981	1.497	0.949	1.094
Efficiency (2010-1)	1.052	1.011	1	1.101	1.339	1.138	0.989	1.142	0.933	1.124	0.899	1.060
Efficiency (2011-1)	1.146	1.217	1	1.141	1.572	1.055	1.026	1.943	0.886	1.366	1.082	1.192
Efficiency (2012-1)	1.108	1.017	1	1.098	1.206	0.950	1.124	1.063	0.886	1.042	0.874	1.029
Efficiency (2013-1)	1.284	1.027	1	1	1.257	1.003	0.980	1.031	0.880	1.311	1.173	1.077
Efficiency (2014-1)	1.297	1.004	1	1	1.662	1.207	0.997	1.181	1.343	1.555	0.955	1.179
Efficiency(t-1): GM	1.148	1.124	1	1.514	1.359	1.053	1.028	1.288	1.001	1.349	0.995	1.157
Efficiency (2006+1)	1.109	1.025	1	1.047	1.209	1.546	1.093	1.553	0.975	0.990	1	1.125
Efficiency (2007+1)	1.237	0.946	1	2.190	1.343	0.945	0.966	1.374	1.196	1.007	1	1.162
Efficiency (2008+1)	1.223	1.049	1	1.811	1.126	0.937	1.032	1.214	1.006	0.980	1.482	1.146
Efficiency (2009+1)	0.994	1.018	1	4.344	1.033	1.186	0.949	1.845	0.882	2.425	0.932	1.306
Efficiency (2010+1)	1.144	1.172	1	1.734	1.069	0.978	1.843	1.114	0.918	1.086	0.901	1.146
Efficiency (2011+1)	1.516	1.957	1	1	3.252	1.023	1.067	2.220	0.889	1.777	1	1.388
Efficiency (2012+1)	0.992	1.001	1	1.048	1.014	1.019	1.416	1.204	0.874	1.204	1.068	1.068
Efficiency (2013+1)	1.034	1.027	1	1.127	1.008	0.945	0.968	1.034	0.867	1.097	0.969	1.004
Efficiency(t+1): GM	1.146	1.118	1	1.570	1.269	1.057	1.137	1.399	0.946	1.252	1.032	1.163

Different from the BCC model, the CCR model does not show any “benchmark” bank (See: Table 4). According to this model, none of the banks has an efficiency scores equal to 1. Generally, all banks have little differences in efficiency scores except Bank3 and Bank4 which has irregular differences in efficiency scores during the period analyzed. Bank3 has the highest geometric mean efficiency based on the t-1 (efficiency score 2.912) and on t+1 (efficiency score 5.05). This may be due to efficiency scores in (2014-1) and (2011+1) that reflects lost in the net profit (NP) in these years falling down from (23,666,396)ALL in year 2011 to (87,706,715) ALL in 2012 and experiencing an increase from (114,019,765)ALL in 2013 to 97,173,848 ALL in 2014. Bank9 seems to have the least geometric mean efficiency scores for t-1 and t+1 models of CCR.

The efficiency changes (technical efficiency) of banks presented in Table 5 shows how the efficiency of banks changes over years. The measures of these changes are derived by means of calculating the ratio of efficiency from one year to another year. For example the efficiency change for the year 2006 to 2007 is calculated as follows;

Efficiency Change (2006 TO 2007) = Efficiency (2007) / Efficiency (2006)

Table 4: Efficiencies of Banks compared to t-1 and t+1 year. CCR-model

DMU	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	GM
Efficiency (2007-1)	1.087	1.387	3.385	2.213	1.385	0.934	1.104	1.198	0.983	1.196	1.024	1.331
Efficiency (2008-1)	0.976	1.039	1.452	8.775	1.263	0.950	0.944	1.116	0.904	0.997	0.987	1.275
Efficiency (2009-1)	0.960	0.978	6.393	0.998	1.210	0.983	0.904	1.033	0.829	1.258	0.816	1.171
Efficiency (2010-1)	1.052	1.010	1.198	1.089	1.331	1.022	0.971	1.131	0.927	1.073	0.891	1.057
Efficiency (2011-1)	0.972	1.027	2.129	1.108	1.418	0.936	1.004	1.257	0.884	1.146	1.015	1.136
Efficiency (2012-1)	1.041	1.016	1.080	1.067	1.121	0.869	0.995	1.045	0.882	1.023	0.828	0.993
Efficiency (2013-1)	1.228	1.024	1.210	7.515	1.414	1.003	0.977	1.006	0.874	1.283	1.078	1.309
Efficiency (2014-1)	1.218	1.001	49.39	1.064	1.569	0.979	0.988	1.162	0.948	1.225	0.887	1.541
Efficiency(t-1): GM	1.062	1.054	2.912	1.939	1.332	0.958	0.984	1.115	0.903	1.146	0.936	1.216
Efficiency (2006+1)	1.084	0.992	2.326	1.015	1.204	1.499	1.009	1.518	0.974	0.944	0.987	1.183
Efficiency (2007+1)	1.230	0.924	2.294	1.240	1.337	0.934	0.955	1.374	1.188	0.960	1.006	1.178
Efficiency (2008+1)	1.185	1.049	2.732	1.750	1.105	0.936	1.008	1.214	0.992	0.977	1.184	1.216
Efficiency (2009+1)	0.994	1.013	3.275	4.287	0.985	0.990	0.945	1.007	0.870	1.302	0.919	1.268
Efficiency (2010+1)	1.087	1.025	4.823	1.669	1.064	0.975	1.049	1.044	0.910	1.009	0.821	1.204
Efficiency (2011+1)	1.296	1.890	266.5	3.872	2.781	1.003	1.028	1.721	0.884	1.581	1.134	2.458
Efficiency (2012+1)	0.983	0.999	6.671	1.019	1.013	0.939	0.954	1.100	0.872	1.093	0.954	1.178
Efficiency (2013+1)	0.999	1.025	1.032	1.102	1.005	0.852	0.964	1.007	0.863	1.039	0.950	0.983
Efficiency(t+1): GM	1.102	1.086	5.050	1.696	1.231	1.002	0.988	1.225	0.939	1.096	0.989	1.284

This means that if the efficiency score of coming year is higher compared to the current year efficiency score, the efficiency change score should be greater than 1 indicating the ratio of change in efficiency if it is efficient and less than 1 representing less efficiency compared to the previous year. For instance, the Bank6 with a score of efficiency change 0.957 for (2006-2007) indicates that this bank is less efficient in year 2007 compared to year 2006. According to geometric mean of efficiency change score for all years from 2006 to 2014, the bank1, bank3, bank4, bank5, bank7, bank8, bank10 had no change and bank2, bank6, bank11 faced inefficiencies, while the bank9 have higher efficiency change over the years compared to others.

Table 5: Efficiency Change of banks, years T to T+1(BCC)

DMU	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	GM
Eff. Change (2006-2007)	1	1	1	1	1	0.957	0.996	1	1.018	1	1	0.997
Eff. Change (2007-2008)	1	0.990	1	1	1	0.993	1.004	1	0.990	1	1	0.998
Eff. Change (2008-2009)	1	1.011	1	1	1	1.052	0.961	1	0.921	1	0.999	0.994
Eff. Change (2009-2010)	1	1	1	1	1	1	1.041	1	0.988	1	0.884	0.991
Eff. Change (2010-2011)	0.986	1	1	1	1	0.883	1	1	0.988	1	1.076	0.993
Eff. Change (2011-2012)	1.014	1	1	1	1	1.083	1	1	1.127	1	1.052	1.024
Eff. Change (2012-2013)	1	1	1	1	1	1.046	0.954	1	0.871	1	1	0.987
Eff. Change (2013-2014)	1	0.992	1	1	1	0.980	1.049	1	1.148	1	0.952	1.010
Efficiency Change: GM	1	0.999	1	1	1	0.997	1	1	1.003	1	0.994	0.999

Compared to the BCC, the CCR model has some different efficiency scores at the mean efficiency of banks B6, B9, B10 and B11 (See: Table 6). Bank10 has the largest mean efficiency score 1.004 and Bank6 has the least mean efficiency score 0.980. Even though the Bank10 has the largest mean efficiency score, Bank9 has hit the top efficiency change during the period 2011-2012. Moreover, this is the period when the banks have had the largest positive mean efficiency change 1.028.

Table 6: Efficiency Change of banks, years T to T+1(CCR)

DMU	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	GM
Eff. Change (2006-2007)	1	1	1	1	1	0.928	0.947	1	1.013	1.008	1	0.990
Eff. Change (2007-2008)	1	0.954	1	1	1	1.012	1.009	1	0.930	1.005	0.997	0.991
Eff. Change (2008-2009)	1	1.048	1	1	1	1.058	0.996	1	0.968	1.019	0.955	1.004
Eff. Change (2009-2010)	1	1	1	1	1	1.007	1.025	1	1.012	1	0.895	0.994
Eff. Change (2010-2011)	0.973	1	1	1	1	0.873	1.026	1	0.985	1	1.093	0.994
Eff. Change (2011-2012)	1.028	1	1	1	1	1.083	1	1	1.131	1	1.074	1.028
Eff. Change (2012-2013)	1	1	1	1	1	0.989	0.951	1	0.871	1	1	0.982
Eff. Change (2013-2014)	1	0.991	1	1	1	0.913	1.052	1	1.037	1	0.890	0.988
Efficiency Change: GM	1	0.999	1	1	1	0.980	1	1	0.991	1.004	0.985	0.996

In addition to efficiency change the DEA frontier analysis also provides the productivity changes between two periods that is defined by the Malmquist productivity index as shown in Table 7. In other words the Malmquist index shows how the banks have been productive from year to year based on the given inputs and outputs. As it can be observed from Table 7, the most productive banks among all banks in Albania were Bank1 Bank2, Bank5, Bank9, Bank10 and least productive banks are Bank4, Bank6, Bank7, Bank8, and Bank11, while the Bank3 had no any productivity change over the years from 2006 to 2007. In the period analyzed the highest technological change and Malmquist index is recorded by Bank4 at period 2007-2008 with productivity score of 2.005 while having the lowest productivity during the period 2009-2010 with a score of 0.503. It is important to state that, for some banks which have an efficiency score equals to 1, the score of Malmquist index and the technological change appears to be the same for the periods of 2006-2014 while for banks that has an efficiency score of less than 1 has different Malmquist index and

Technological change scores. This indicates that, the productivity of the banks for the particular period is highly related with the technological change along with the efficiency change for the corresponding periods.

Table 7: Malmquist Index of Banks and Technological changes over years (BCC-model)

DMU	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	GM
Tech Chan(2006-2007)	0.990	1.243	1	1.465	1.074	0.812	1.009	0.956	1.096	1.309	1.036	1.077
Tech Chan(2007-2008)	1.012	1.153	1	2.005	0.979	1.017	1.038	0.982	0.917	1.145	0.996	1.086
Tech Chan(2008-2009)	0.898	0.973	1	0.748	1.043	1.085	0.986	1.076	1.029	1.236	0.801	0.980
Tech Chan(2009-2010)	1.029	0.996	1	0.503	1.139	0.980	1	0.787	1.035	0.681	1.045	0.905
Tech Chan(2010-2011)	1.008	1.019	1	0.811	1.212	1.106	0.746	1.321	0.988	1.121	1.056	1.023
Tech Chan(2011-2012)	0.849	0.721	1	1.048	0.609	0.926	1.027	0.692	0.940	0.766	0.911	0.851
Tech Chan(2012-2013)	1.137	1.013	1	0.977	1.113	0.970	0.852	0.925	1.075	1.044	1.048	1.011
Tech Chan(2013-2014)	1.120	0.993	1	0.942	1.284	1.142	0.991	1.069	1.162	1.191	1.018	1.078
Tech Change: GM	1.001	1.003	1	0.982	1.035	0.999	0.951	0.959	1.028	1.038	0.985	0.998
Malm.Ind(2006-2007)	0.990	1.243	1	1.465	1.074	0.777	1.005	0.956	1.116	1.309	1.036	1.074
Malm.Ind(2007-2008)	1.012	1.141	1	2.005	0.979	1.010	1.042	0.982	0.908	1.145	0.996	1.084
Malm.Ind(2008-2009)	0.898	0.984	1	0.748	1.043	1.141	0.948	1.076	0.948	1.236	0.800	0.974
Malm.Ind(2009-2010)	1.029	0.996	1	0.503	1.139	0.980	1.041	0.787	1.022	0.681	0.924	0.897
Malm.Ind(2010-2011)	0.994	1.019	1	0.811	1.212	0.976	0.746	1.321	0.977	1.121	1.137	1.016
Malm.Ind(2011-2012)	0.861	0.721	1	1.048	0.609	1.003	1.027	0.692	1.060	0.766	0.959	0.871
Malm.Ind(2012-2013)	1.137	1.013	1	0.977	1.113	1.015	0.812	0.925	0.937	1.044	1.048	0.998
Malm.Ind(2013-2014)	1.120	0.985	1	0.942	1.284	1.119	1.039	1.069	1.333	1.191	0.968	1.089
Malm.Ind: GM	1.001	1.002	1	0.982	1.035	0.997	0.951	0.959	1.030	1.038	0.979	0.997

However, the results for the CCR model (See: Table 8) have not been the same as that of BCC. For instance, while Bank3 has a mean technology change and a mean Malmquist index productivity of 1 according to the BCC model, this bank seems to has the least mean technological change score and Malmquist index productivity score in the CCR. This difference may again, come from the indirect factors that have an impact in the efficiency of banks based on the CCR model. According to the BCC model, Bank10 has the largest mean technological change and Malmquist index productivity score, while based on the CCR model the top mean technological change and Malmquist index productivity is recorded by Bank7. As Table 8 shows, during the period 2012-2013 all the banks have experienced an enormous increase in the technological change and Malmquist index. However, the following period has been the time when the geometric mean of all banks for that period has hit the bottom score equally to 0.182 for the technological change and 0.183 for the Malmquist Index productivity. Based on the CCR model, Bank5 has the largest increase of technological change at period 2012-2013 showing a score of 9.717. The least score is recorded at period 2011-2012 by Bank3 equally to 0.064.

Table 8: Malmquist Index of Banks and Technological changes over years (CCR-model)

DMU	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	GM
Tech Chan(2006-2007)	1.001	1.182	1.206	1.476	1.073	0.820	1.075	0.888	0.998	1.121	1.018	1.066
Tech Chan(2007-2008)	0.891	1.086	0.796	2.661	0.972	1.003	0.990	0.901	0.904	1.016	0.992	1.045
Tech Chan(2008-2009)	0.900	0.943	1.530	0.755	1.047	0.996	0.949	0.923	0.929	1.124	0.850	0.979
Tech Chan(2009-2010)	1.029	0.999	0.605	0.504	1.162	1.013	1.001	1.060	1.026	0.908	1.041	0.916
Tech Chan(2010-2011)	0.959	1.001	0.664	0.815	1.154	1.048	0.966	1.097	0.993	1.066	1.064	0.974
Tech Chan(2011-2012)	0.884	0.733	0.064	0.525	0.635	0.894	0.984	0.779	0.939	0.805	0.824	0.627
Tech Chan(2012-2013)	8.950	7.971	5.249	9.087	9.717	8.377	8.306	7.540	8.565	8.232	8.275	8.120
Tech Chan(2013-2014)	0.133	0.147	1.551	0.181	0.125	0.147	0.184	0.139	0.140	0.146	0.139	0.182
Tech Chan: GM	0.977	1.005	0.862	1.006	1.015	0.994	1.049	0.956	0.995	1.023	0.987	0.987
Malm. Ind(2006-2007)	1.001	1.182	1.206	1.476	1.073	0.760	1.018	0.888	1.011	1.130	1.018	1.055
Malm. Ind(2007-2008)	0.891	1.036	0.796	2.661	0.972	1.015	0.999	0.901	0.841	1.022	0.989	1.036
Malm. Ind(2008-2009)	0.900	0.989	1.530	0.755	1.047	1.054	0.945	0.923	0.900	1.145	0.812	0.983
Malm. Ind(2009-2010)	1.029	0.999	0.605	0.504	1.162	1.019	1.026	1.060	1.038	0.908	0.931	0.910
Malm. Ind(2010-2011)	0.933	1.001	0.664	0.815	1.154	0.916	0.991	1.097	0.978	1.066	1.163	0.969
Malm. Ind(2011-2012)	0.909	0.733	0.064	0.525	0.635	0.968	0.984	0.779	1.062	0.805	0.886	0.644
Malm. Ind(2012-2013)	8.950	7.971	5.249	9.087	9.717	7.715	7.885	7.540	7.391	8.232	7.573	7.851
Malm. Ind(2013-2014)	0.133	0.145	1.551	0.181	0.125	0.144	0.194	0.139	0.146	0.146	0.135	0.183
Malm. Ind: GM	0.977	1.004	0.862	1.006	1.015	0.975	1.049	0.956	0.986	1.027	0.973	0.983

3.3.2. Stochastic Frontier Analysis

Apart from the DEA frontier analysis, it has been used the Stochastic Frontier Analysis (SFA) for each output used in the previous methods. SFA analysis comprised of Cobb Douglas cost function and Cobb Douglas production function as it was indicated at the methodology part of the thesis.

Based on the Cobb Douglass cost function analysis, assets were used as an output independent variable and showed (See: Table 9) that the coefficient effect of dependent variable beta 1 (Loans) has a coefficient score of 0.082, beta 2 (Liabilities) with coefficient of 0.76 and beta 3 (Number of Employees) with score of 0.14. All these inputs has a positive effect on the independent variable assets while the beta 4 (Number of outlets) with a coefficient score of -0.003, indicating that the banks in Albania has more branches than needed.

3.3.2.1. Cobb Douglas cost function

Dependent variable as assets:

Table 9: The OLS estimates for assets as output, Cobb Douglas cost function

	coefficient	standard-error	t-ratio
beta 0	0.30096698E	0.64222211E	0.46863380E
beta 1	0.82901762E-01	0.34993038E-01	0.23690930E
beta 2	0.76792988E	0.41029641E-01	0.18716466E
beta 3	0.14064030E	0.56412477E-01	0.24930708E
beta 4	-0.31055406E-02	0.68954697E-01	-0.45037405E-01
sigma-squared 0.17121150E-01			
Log likelihood function = 0.63428746E			

Moreover, the SFA gives us the Maximum Likelihood Estimates for the given dependent variables on the independent variable. This indicates the impact of dependent variables at maximum probability to the independent variable. As it is shown in Table 10, the coefficient estimates of dependent variables have increased to certain points. For example, the coefficient of beta 4 was negative while with the maximum likelihood estimates it increased from negative coefficient of -0.0031 to positive coefficient of 0.0936.

Table 10: The final MLE estimates for assets, Cobb Douglas Cost Function

	coefficient	standard-error	t-ratio
beta 0	0.48728890E	0.59860883E	0.81403561E
beta 1	0.29190603E	0.35605089E-01	0.81984357E
beta 2	0.47060779E	0.36121998E-01	0.13028288E
beta 3	0.12371025E	0.46722730E-01	0.26477530E
beta 4	0.93623905E-01	0.63916346E-01	0.14647881E
sigma-squared	0.77622729E-01	0.34370036E-01	0.22584419E
gamma	0.92021977E	0.37720273E-01	0.24395894E
mu is restricted to be zero eta is restricted to be zero log likelihood function = 0.92316622E			

Based on the evaluation of banking sector cost to serve the independent variable (assets) with a given dependent variables namely; loans, liabilities, number of employees and number of outlets as shown in Table 11 is equivalent to mean efficiency value of 0.12. This indicates that the cost of serving in Albanian banking sector is too costly amounting around 88 percent. According to the Table 11, it can be observed that, the least costly bank in Albanian banking sector is bank 8 while the most costly one is bank 7.

Table 11: Cost efficiency estimates for assets, Cobb Douglas Cost Function

firm	eff.-est.
1	0.14617881E
2	0.11650306E
3	0.14434263E
4	0.12571088E
5	0.15555376E
6	0.10587947E
7	0.10287004E
8	0.14936669E
9	0.11539554E
10	0.12346119E
11	0.10298220E
mean efficiency	0.12620402E

Dependent Variable as Deposits:

Table 12: The OLS estimates for Deposits, Cobb Douglass Cost Function

	coefficient	standard-error	t-ratio
beta 0	0.20951365E+01	0.11843684E+01	0.17689905E+01
beta 1	0.22446894E+00	0.64533204E-01	0.34783480E+01
beta 2	0.63520644E+00	0.75665742E-01	0.83949014E+01
beta 3	0.76363855E-01	0.10403435E+00	0.73402542E+00
beta 4	0.26051602E+00	0.12716437E+00	0.20486558E+01
sigma-squared 0.58228563E-01			
log likelihood function = 0.28377021E+01			

Different from the previous function when the assets were chosen as the output, this function (deposits chosen as the output function) results, seems to have some differences. Based on the OLS estimates (See: Table 12), the largest impact on the deposits is caused by the independent variable *liabilities*, showing a coefficient score of beta2=0.635, followed by the input variable *NRBR* impact coefficient score beta4=0.26, dependent variable *TL* coefficient beta1=0.224 and beta3=0.076 indicating that deposits are less effected by the numbers of employees of a banks.

Table 13: The final MLE estimates for Deposits, Cobb Douglass Cost Function

	coefficient	standard-error	t-ratio
beta 0	0.51531458E+01	0.12914879E+01	0.39900844E+01
beta 1	0.25315577E+00	0.71495115E-01	0.35408820E+01
beta 2	0.43705602E+00	0.78315730E-01	0.55806927E+01
beta 3	0.14219401E+00	0.12624526E+00	0.11263314E+01
beta 4	0.39367746E+00	0.13849639E+00	0.28425105E+01
sigma-squared	0.13633172E+00	0.66940177E-01	0.20366202E+01
gamma	0.78275699E+00	0.11620759E+00	0.67358507E+01
mu is restricted to be zero eta is restricted to be zero log likelihood function = 0.20716794E+02			

As expected, the coefficients from the MLE methods are larger (except beta2) than the OLS estimates and the dependent variables coefficient scores have some differences. Based on the MLE, again the dependent variable *liabilities* has the largest coefficient score of beta2=0.437 and the dependent variable *NREMP* has the smallest coefficient score beta3=0.142. The mean efficiency score of banks is 1.335 showing that the banks have done very well with the deposits during the period analyzed and this indicates the main activity operation of banks in Albania. That is, with this quantity of inputs all the banks have gathered more deposits than the expectations.

Table 14: Cost efficiency estimates for Deposits, Cobb Douglass Cost Function

firm	eff.-est.
1	0.14777804E+01
2	0.13598555E+01
3	0.10343688E+01
4	0.17266701E+01
5	0.17700761E+01
6	0.10854423E+01
7	0.11169779E+01
8	0.14005055E+01
9	0.12458137E+01
10	0.11562479E+01
11	0.13216541E+01
mean efficiency	0.13359447E+01

Dependent Variable as Equity Capital:

Table 15: The OLS estimates for Equity Capital, Cobb Douglass Cost Function

	coefficient	standard-error	t-ratio
beta 0	0.56940805E	0.21109676E	0.26973794E
beta 1	-0.22337478E-01	0.11502122E	-0.19420311E
beta 2	0.74997297E	0.13486338E	0.55609831E
beta 3	-0.20367497E	0.18542637E	-0.10984143E
beta 4	0.44274954E-01	0.22665232E	0.19534304E
sigma-squared 0.18498033E			
log likelihood function = -0.54378036E			

The results in Table 15 show that *total liabilities* variable has the largest coefficient score (beta2=0.749) of impact at equity capital. The *number of outlets* variable has a positive coefficient of beta4=0.0442. However, the coefficient score of *loans* and *number of employees* are negative, beta1=-0.223 and beta3=-0.203 respectively. This indicates that banks over use these two independent variables in order to have the same quantity of equity capital.

Table 16: The final MLE estimates for Equity Capital, Cobb Douglass Cost Function

	coefficient	standard-error	t-ratio
beta 0	0.17450164E	0.19917142E	0.87613791E
beta 1	0.62765272E	0.12296611E	0.51042739E
beta 2	0.26762349E	0.11708217E	0.22857749E
beta 3	-0.43592051E	0.23323857E	-0.18689898E
beta 4	0.36659329E	0.21413453E	0.17119765E
sigma-squared	0.89567686E	0.41563610E	0.21549544E
gamma	0.92419794E	0.38458076E-01	0.24031310E
mu is restricted to be zero eta is restricted to be zero log likelihood function = -0.26279386E			

Based on the MLE results (see Table 16), the dependent variable *loans* has the maximum coefficient score of beta1=0.627 and the variable number of employees has the smallest coefficient beta3=-0.435. During the period analyzed banks have a mean cost efficiency of 25.9% telling that the services provided are very expensive. The largest cost efficiency is recorded by bank4 (0.257) and the least one is experienced by bank2.

Table 17: Cost efficiency estimates for Equity Capital, Cobb Douglass Cost Function

firm	eff.-est.
1	0.15356835E
2	0.10748051E
3	0.11654510E
4	0.25771003E
5	0.20115886E
6	0.12914449E
7	0.15840722E
8	0.20128630E
9	0.13309890E
10	0.17042868E
11	0.18017646E
mean efficiency	0.25981007E

3.3.2.2.Cobb Douglas production function

Cobb Douglas production function measures the technical efficiency of each particular bank in the period analyzed. Assets, deposits and equity capital were used as independent variables separately, with the same inputs: loans, total liabilities, number of employees and number of outlets (branches + agencies). The following results show the relationship between inputs and the output respectively.

Dependent variable as assets:

Table 18: The OLS estimates for assets, Cobb Douglas Production Function

	coefficient	standard-error	t-ratio
beta 0	0.30096698E	0.64222211E	0.46863380E
beta 1	0.82901762E-01	0.34993038E-01	0.23690930E
beta 2	0.76792988E	0.41029641E-01	0.18716466E
beta 3	0.14064030E	0.56412477E-01	0.24930708E
beta 4	-0.31055406E-02	0.68954697E-01	-0.45037405E-01
sigma-squared 0.17121150E-01			
log likelihood function = 0.63428746E			

Based on the OLS estimates, *TLI* variable has the largest impact score of 0.767 and *NRBR* has the coefficient score of -0.0031 on the independent variable *TA*. Different from OLS, MLE estimates show an increase of the coefficient score of the dependent variables. Again, *TLI* has the largest coefficient score beta2 =0.470 followed by TL coefficient of beta1=0.301, beta3=0.161 and beta4=0.048.

Table 19: The final MLE estimates for assets, Cobb Douglas Production Function

	coefficient	standard-error	t-ratio
beta 0	0.50227657E	0.56297523E	0.89218236E
beta 1	0.30119122E	0.35026314E-01	0.85989983E
beta 2	0.47029228E	0.37153884E-01	0.12657957E
beta 3	0.16180635E	0.67060340E-01	0.24128472E
beta 4	0.48460505E-01	0.62671744E-01	0.77324327E
sigma-squared	0.72776355E-01	0.32356427E-01	0.22492086E
gamma	0.91426979E	0.41391238E-01	0.22088486E
mu is restricted to be zero			
eta is restricted to be zero			
log likelihood function = 0.92362383E			

Table 20 shows the technical efficiency estimates for each bank during the period analyzed 2006-2014. Technical efficiency measures the ability of a firm to obtain maximal output using a given set of inputs. From the data presented in Table 20, the average technical efficiency seems to be 81.7% indicating that these banks should reduce the volume of inputs by 19.3% in order to become efficient. Bank5 has the largest technical efficiency equal to 97.7% managing its inputs efficiently. Bank7 is the one which uses these inputs in the minimum efficiency level. It should reduce its inputs quantity by 34.8% in order to catch the efficiency frontier.

Table 20: Technical efficiency estimates for assets, Cobb Douglas Production Function

firm	eff.-est.
1	0.94355368E
2	0.75337618E
3	0.95061528E
4	0.83037524E
5	0.97750415E
6	0.68905802E
7	0.65253270E
8	0.95783502E
9	0.75913817E
10	0.80768661E
11	0.67205709E
mean efficiency	0.81761201E

Dependent variable as Deposits:

Table 21: The OLS estimates for deposits, Cobb Douglas Production Function

	coefficient	standard-error	t-ratio
beta 0	0.20951365E+01	0.11843684E+01	0.17689905E+01
beta 1	0.22446894E+00	0.64533204E-01	0.34783480E+01
beta 2	0.63520644E+00	0.75665742E-01	0.83949014E+01
beta 3	0.76363855E-01	0.10403435E+00	0.73402542E+00
beta 4	0.26051602E+00	0.12716437E+00	0.20486558E+01
sigma-squared 0.58228563E-01			
log likelihood function = 0.28377021E+01			

As it is seen from Table 21, again the independent variable *total liabilities* with a coefficient score beta2=0.635 has the largest impact on the independent variable deposits. In the same way as in the Cobb Douglas cost function method, the results show that the number of employees beta3=0.076 has very little impact on the quantity of deposits and these two variables have not a strong correlation with each other.

Table 22: The final MLE estimates for deposits, Cobb Douglas Production Function

	coefficient	standard-error	t-ratio
beta 0	0.63926146E+01	0.15255086E+01	0.41904809E+01
beta 1	0.19481946E+00	0.72379229E-01	0.26916487E+01
beta 2	0.48077738E+00	0.79404072E-01	0.60548202E+01
beta 3	0.15692043E+00	0.15053078E+00	0.10424475E+01
beta 4	0.26791030E+00	0.13171182E+00	0.20340642E+01
sigma-squared	0.21031203E+00	0.12621148E+00	0.16663462E+01
gamma	0.87738976E+00	0.80988394E-01	0.10833525E+02
mu is restricted to be zero eta is restricted to be zero log likelihood function = 0.24239018E+02			

According to MLE estimates (Table 22), the independent variable *total liabilities* has an impact score of 0.48 on the deposits while the coefficient impact score of beta3=0.156. The average technical efficiency of banks is 73.2% showing that the used inputs should be reduced by 26.8% in order to be efficient. The largest efficiency is recorded by the Bank5 with an efficiency score of 96.2 percent and the efficiency bottom is represented by Bank3 with an efficiency percentage of 36.8.

Table 23: Technical efficiency estimates for deposits, Cobb Douglas Production Function

firm	eff.-est.
1	0.90454648E+00
2	0.79489444E+00
3	0.36821321E+00
4	0.80187771E+00
5	0.96229517E+00
6	0.60648155E+00
7	0.63498783E+00
8	0.90588346E+00
9	0.72436546E+00
10	0.70766977E+00
11	0.64652492E+00
mean efficiency	0.73252182E+00

Dependent Variables as Equity Capital for production function:

Table 24: The OLS estimates for equity Capital, Cobb Douglas Production Function

	coefficient	standard-error	t-ratio
beta 0	0.56940805E	0.21109676E	0.26973794E
beta 1	-0.22337478E-01	0.11502122E	-0.19420311E
beta 2	0.74997297E	0.13486338E	0.55609831E
beta 3	-0.20367497E	0.18542637E	-0.10984143E
beta 4	0.44274954E-01	0.22665232E	0.19534304E
sigma-squared 0.18498033E			
log likelihood function = -0.54378036E			

The OLS estimates of the production function when the equity capital is the independent variable and the dependent variables are the same as previous ones are shown on Table 24. The independent variable *total liabilities* has the largest coefficient score beta2= 0.749. Different from the previous results, in this case variables *loans* and *number of employees* has a negative impact on the equity capital. This indicates that if the number of employees increases the expenses of the firm will be higher resulting on lower net income, which means less flow of cash to creditors.

Table 25: The final MLE estimates for equity Capital, Cobb Douglas Production Function

	coefficient	standard-error	t-ratio
beta 0	0.43959357E	0.19887391E	0.22104135E
beta 1	0.63228162E	0.12631835E	0.50054612E
beta 2	0.25777461E	0.11887121E	0.21685201E
beta 3	-0.42959095E	0.23952486E	-0.17935130E
beta 4	0.32129897E	0.22088126E	0.14546230E
sigma-squared	0.34402128E	0.18629403E	0.18466576E
gamma	0.98006253E	0.11803304E-01	0.83032899E
mu is restricted to be zero eta is restricted to be zero log likelihood function = -0.34214726E			

The mean technical efficiency of equity capital used as an independent variable is 0.222 (see; Table 26). Bank3 has the largest technical efficiency of 91.6%. This shows that Bank3 uses the inputs in an efficient way in order to have a high technical efficiency of equity capital. Moreover we used the (Battese & Coelli, 1992) model in order to measures the cost and technical efficiency of each bank in each year. The Appendix B shows the results of the used method for each independent variable separately.

Table 26: Technical efficiency for equity Capital, Cobb Douglas Production Function

firm	eff.-est.
1	0.14523488E
2	0.92184840E-01
3	0.91642037E
4	0.22073661E
5	0.18505818E
6	0.11646229E
7	0.14431186E
8	0.19435560E
9	0.12277799E
10	0.15886894E
11	0.15468846E
mean efficiency	0.22282727E

Conclusion

The aim of this thesis is to show the Albanian banking sector efficiency during the period 2006-2014. Due to the lack of data, only 11 banks (which compose nearly 88% of banking sector assets) were taken to be analyzed. Using a mathematical method named DEA-data envelopment analysis and an econometric method called SFA-stochastic frontier analysis, it estimates the cost and technical efficiency of banks. DEA method is a determinist method and it uses the linear programming in order to measure the efficiency by creating efficiency frontiers. It does not take into account the random errors assuming that all deviations are done by the company. Different from DEA, SFA method requires a predefinition of the functional form and also it separates the random error from the inefficiency.

In general the both SFA and the DEA frontier analysis demonstrates the technical efficiencies of the banks, the two models has its own distinctive features like; cost estimation and coefficient weightings in SFA, while the DEA frontier measures the Malmquist index productivity. This means that with the DEA frontier analysis it shows the efficiency scores and suggestion on use of inputs and outputs to reach the efficiency frontier, while the SFA gives us the impact of each input on output used in the analysis.

The results from these two methods show that the Albanian banking sector has low cost efficiency in assets, equity capital, and high cost efficiency in deposits while for all outputs has high technical efficiency. This indicates that the services offered by banks are very expensive in regard to equity capital and assets. The high cost efficiency in deposits in turn indicates that the banks have too much liquidity that the interest rate offered for the deposits are lower. It is observed that the most influential input appears to be the total liabilities with a higher coefficient score for all dependent variables as assets, equity capital and the deposits. Considering the amount of non-performing loans which have been increasing over the years can be suggested as a true factor regarding the impact of total liabilities to meet the projected asset production and equity capital requirements.

Even though the results about technical efficiency are good, there is more to be done in order to reach the efficiency frontier. The results of DEA showed the quantity of inputs that is overused and the quantity of outputs that should be ideal in order to operate at the efficiency level.

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APPENDIX A

Figure 1: Shareholders, Equity Share, Ownership and Capital origin of banks (2013)

No.	Banks	Shareholders	Equity share	Ownership	Capital origin	Home country
1.	RAIFFEISEN BANK	Raiffeisen SEE Region Holding GmbH	100	Private	Foreign	Austria
2.	NATIONAL COMMERCIAL BANK	Çalik Finansal Hizmetler A.S.	100	Private	Foreign	Turkey
3	UNITED BANK OF ALBANIA	Islamic Development Bank (IDB) Jeddah	86.70	Private	Foreign	Saudi Arabia
		Ithmaar Bank (former Shamil Bank of Bahrein)	4.63	Private	Foreign	Kingdom of Bahrain
		Dallah Albaraka Holding	2.32	Private	Foreign	Saudi Arabia
		Business Fokus SDN BHD	1.47	Private	Foreign	Saudi Arabia Malaysia
		Individuals	4.88	Private	Foreign	Saudi Arabia
4	INTESA SANPAOLO BANK ALBANIA	Intesa Sanpaolo S.p.A (ISP)	98.61	Private	Foreign	Italy
		Italian Association for the enterprises operating abroad S.p.a (SIMEST)	1.39	Private	Foreign	Italy
5	Tirana Bank	Piraeus Bank	98.48	Private	Foreign	Greece
		Tzivelis Ioannis	1.52	Individual	Foreign	Greece
6	NBG BANK ALBANIA	National Bank of Greece	100.00	Private	Foreign	Greece
7	ALPHA BANK ALBANIA	Alpha Bank, Greece	100.00	Private	Foreign	Greece
8	VENETO BANK	Veneto Banca Holding	100.00	Private	Foreign	Italy
9	PROCREDIT BANK	ProCredit Holding A.G.	100.00	Private	Foreign	Germany
10	INTERNATIONAL COMMERCIAL BANK	Financial Group ICB Holding	100.00	Private	Foreign	Swizerland
11	CREDIT AGRICOLE BANK ALBANIA	IUB HOLDING A.S, FRANCE	100.00	Private	Foreign	France
12	CREDIT BANK OF ALBANIA	8 Individuals	100.00	Private	Foreign	Kuwait
13	CREDINS BANK	15 Individuals	72.85	Private	Domestic	Albania
		B.F.S.E. Holding B.V.	19.53	Private	Foreign	Holland
		State Secretariat for Economic Affairs (SECO) of Switzerland	2.79	Public - Private	Foreign	Switzerland
		Albanian Savings Loan Union	4.83	Private	Doemstic	Albania
14	SOCIETE GENERALE ALBANIA BANK	SOCIETE GENERALE	88.64	Private	Foreign	France
		8 Individuals	11.36	Private	Domestic	Albania
15	UNION BANK	European Bank for Reconstruction and Development (EBRD)	11.18	Private	Foreign	England
		Financial Union Tirana	84.90	Private	Domestic	Albania
		2 Individuals	3.92	Private	Domestic	Albania
16	FIRST INVESTMENT BANK, ALBANIA	First Investment Bank, Bulgaria	100.00	Private	Foreign	Bulgaria

Source: Bank of Albania.

Figure 2: Structure of banking system in Albania in 2013

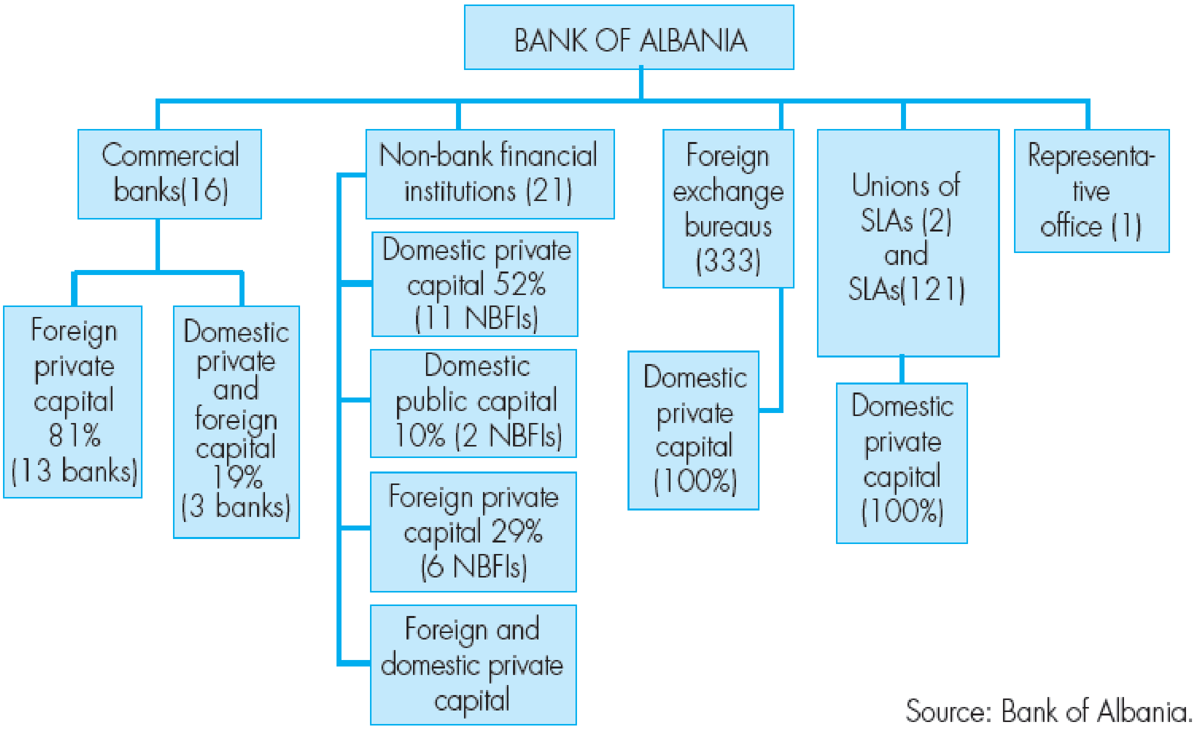
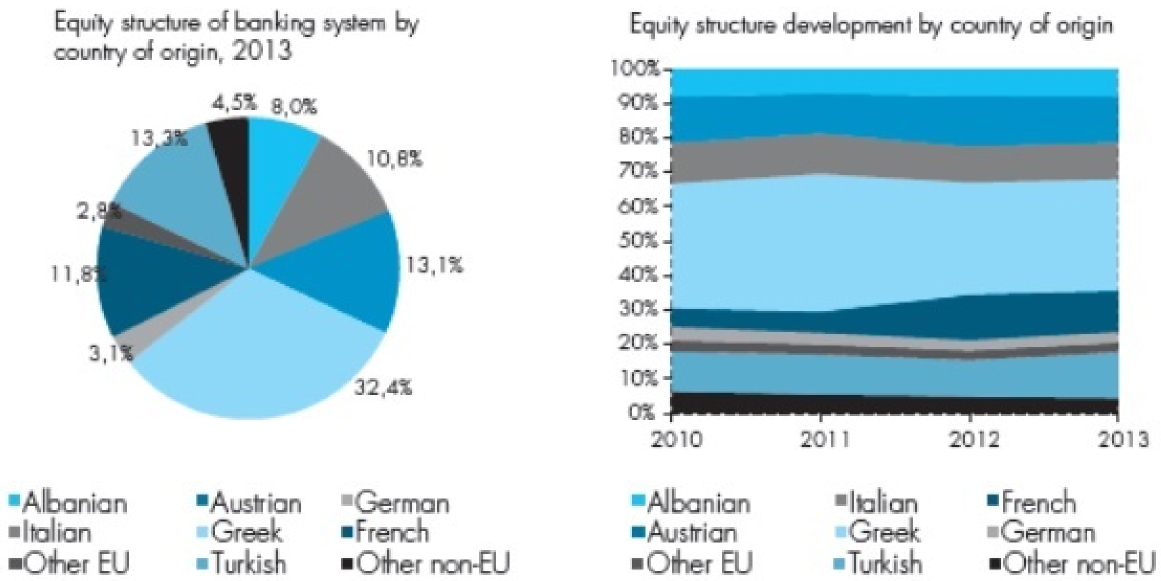


Figure 3: Equity ownership structure by country of origin and performance



Appendix B

Model 1 cost function (assets as output)

B: 1- The OLS Estimates

	coefficient	standard-error	t-ratio
beta 0	0.30096698E	0.64222211E	0.46863380E
beta 1	0.82901762E-01	0.34993038E-01	0.23690930E
beta 2	0.76792988E	0.41029641E-01	0.18716466E
beta 3	0.14064030E	0.56412477E-01	0.24930708E
beta 4	-0.31055406E-02	0.68954697E-01	-0.45037405E-01
sigma-squared 0.17121150E-01			
log likelihood function = 0.63428746E			

B: 2-The final MLE estimates

	coefficient	standard-error	t-ratio
beta 0	0.17090159E	0.13124140E	0.13021927E
beta 1	0.30204347E	0.58370578E-01	0.51745842E
beta 2	0.60709834E	0.10386050E	0.58453249E
beta 3	0.12521410E	0.46246173E-01	0.27075559E
beta 4	-0.12178803E-01	0.70559918E-01	-0.17260229E
sigma-squared	0.41077036E	0.16431351E	0.24999184E
gamma	0.98530319E	0.59268594E-01	0.16624373E
mu	-0.12723731E	0.69056956E	-0.18424981E
eta	-0.94429215E-01	0.51212792E-01	-0.18438599E
log likelihood function = 0.94472263E			

B: 3-Cost efficiency estimates

	eff.-est.								
firm	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
1	0.133	0.129	0.126	0.124	0.121	0.119	0.117	0.115	0.114
2	0.108	0.107	0.106	0.106	0.105	0.105	0.104	0.104	0.103
3	0.218	0.203	0.191	0.180	0.171	0.162	0.155	0.149	0.144
4	0.153	0.147	0.142	0.137	0.133	0.130	0.127	0.124	0.122
5	0.136	0.133	0.129	0.126	0.124	0.121	0.119	0.117	0.115
6	0.102	0.102	0.101	0.101	0.101	0.101	0.101	0.101	0.101
7	0.102	0.102	0.102	0.101	0.101	0.101	0.101	0.101	0.101
8	0.134	0.130	0.127	0.124	0.122	0.120	0.118	0.116	0.114
9	0.115	0.113	0.112	0.111	0.110	0.109	0.108	0.107	0.106
10	0.113	0.112	0.111	0.110	0.109	0.108	0.107	0.106	0.106
11	0.111	0.110	0.109	0.108	0.107	0.107	0.106	0.105	0.105
mean eff	0.130	0.126	0.123	0.121	0.119	0.117	0.115	0.113	0.112

Model 1 cost function (deposits as output)

B: 4-The OLS estimates

	coefficient	standard-error	t-ratio
beta 0	0.20951365E	0.11843684E	0.17689905E
beta 1	0.22446894E	0.64533204E-01	0.34783480E
beta 2	0.63520644E	0.75665742E-01	0.83949014E
beta 3	0.76363855E-01	0.10403435E	0.73402542E
beta 4	0.26051602E	0.12716437E	0.20486558E
sigma-squared 0.58228563E-01			
log likelihood function = 0.28377021E			

B: 5-The final MLE estimates

	coefficient	standard-error	t-ratio
beta 0	0.45682597E	0.18289674E	0.24977261E
beta 1	0.27539792E	0.68198954E-01	0.40381546E
beta 2	0.44333690E	0.72868180E-01	0.60840946E
beta 3	0.14868617E	0.12098528E	0.12289609E
beta 4	0.30346057E	0.13908279E	0.21818700E
sigma-squared	0.75175456E-01	0.26987726E-01	0.27855424E
gamma	0.63820908E	0.97101920E-01	0.65725691E
mu	0.43807606E	0.20733666E	0.21128732E
eta	-0.15664110E-01	0.41724674E-01	-0.37541601E
log likelihood function = 0.22600364E			

B: 6-Cost efficiency estimates

	eff.-est.								
firm	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
1	0.188	0.186	0.184	0.183	0.181	0.179	0.178	0.176	0.174
2	0.166	0.165	0.164	0.162	0.161	0.160	0.159	0.158	0.157
3	0.108	0.107	0.107	0.107	0.107	0.107	0.107	0.107	0.107
4	0.201	0.198	0.196	0.194	0.192	0.190	0.188	0.187	0.185
5	0.214	0.211	0.209	0.206	0.204	0.202	0.199	0.197	0.195
6	0.128	0.127	0.127	0.126	0.126	0.125	0.125	0.125	0.124
7	0.137	0.136	0.135	0.135	0.134	0.134	0.133	0.132	0.132
8	0.182	0.180	0.178	0.177	0.175	0.174	0.172	0.171	0.169
9	0.156	0.155	0.154	0.153	0.152	0.151	0.150	0.149	0.148
10	0.143	0.142	0.142	0.141	0.140	0.139	0.139	0.138	0.137
11	0.151	0.150	0.149	0.148	0.147	0.146	0.145	0.144	0.144
mean eff	0.161	0.160	0.159	0.158	0.156	0.155	0.154	0.153	0.152

Model 1 cost function (equity capital as output)

B: 7- The OLS estimates

	coefficient	standard-error	t-ratio
beta 0	0.56940805E	0.21109676E	0.26973794E
beta 1	-0.22337478E-01	0.11502122E	-0.19420311E
beta 2	0.74997297E	0.13486338E	0.55609831E
beta 3	-0.20367497E	0.18542637E	-0.10984143E
beta 4	0.44274954E-01	0.22665232E	0.19534304E
sigma-squared 0.18498033E			
log likelihood function = -0.54378036E			

B: 8-The final MLE estimates

	coefficient	standard-error	t-ratio
beta 0	0.14957389E	0.19442825E	0.76930124E
beta 1	0.30776274E	0.11654030E	0.26408267E
beta 2	-0.10640552E	0.11323373E	-0.93969809E
beta 3	-0.28746773E-02	0.21989477E	-0.13072968E-01
beta 4	0.43851463E	0.21690743E	0.20216672E
sigma-squared	0.20328117E	0.55656787E-01	0.36524057E
gamma	0.77128090E	0.89658014E-01	0.86024759E
mu	0.79192646E	0.14295584E	0.55396578E
eta	0.79224382E-01	0.83316536E-02	0.95088425E
log likelihood function = -0.74799164E			

B: 9- Cost efficiency estimates

	eff.-est.								
firm	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
1	0.298	0.326	0.359	0.399	0.448	0.507	0.580	0.671	0.785
2	0.201	0.213	0.227	0.243	0.261	0.283	0.309	0.339	0.375
3	0.346	0.383	0.429	0.483	0.551	0.634	0.739	0.871	0.104
4	0.199	0.211	0.224	0.240	0.258	0.279	0.303	0.333	0.367
5	0.384	0.429	0.483	0.551	0.634	0.739	0.872	0.104	0.126
6	0.236	0.253	0.274	0.297	0.325	0.359	0.399	0.447	0.507
7	0.184	0.193	0.204	0.217	0.231	0.248	0.267	0.290	0.317
8	0.378	0.422	0.475	0.541	0.622	0.723	0.852	0.101	0.123
9	0.211	0.224	0.240	0.258	0.279	0.303	0.333	0.367	0.409
10	0.317	0.349	0.387	0.433	0.489	0.557	0.642	0.749	0.884
11	0.211	0.225	0.240	0.258	0.280	0.304	0.334	0.369	0.411
mean eff	0.269	0.293	0.322	0.356	0.398	0.449	0.512	0.591	0.690

Model 1 production function (assets as output)

B: 10-The OLS estimates

	coefficient	standard-error	t-ratio
beta 0	0.30096698E	0.64222211E	0.46863380E
beta 1	0.82901762E-01	0.34993038E-01	0.23690930E
beta 2	0.76792988E	0.41029641E-01	0.18716466E
beta 3	0.14064030E	0.56412477E-01	0.24930708E
beta 4	-0.31055406E-02	0.68954697E-01	-0.45037405E-01
sigma-squared 0.17121150E-01			
log likelihood function = 0.63428746E			

B: 11- The Final MLE estimates

	coefficient	standard-error	t-ratio
beta 0	0.53989453E	0.69772656E	0.77379100E
beta 1	0.29763284E	0.35082021E-01	0.84839138E
beta 2	0.44637241E	0.39221092E-01	0.11380928E
beta 3	0.23183295E	0.84464762E-01	0.27447298E
beta 4	0.12900105E-01	0.73986415E-01	0.17435776E
sigma-squared	0.62569008E-01	0.64827152E-01	0.96516670E
gamma	0.90367785E	0.10093857E	0.89527508E
mu	0.10177487E	0.29783140E	0.34171976E
eta	-0.24868179E-01	0.15510994E-01	-0.16032615E
log likelihood function = 0.93993306E			

B: 12- Technical efficiency estimates

	eff.-est.								
firm	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
1	0.938	0.939	0.940	0.942	0.943	0.945	0.946	0.947	0.948
2	0.733	0.739	0.745	0.750	0.755	0.760	0.766	0.771	0.776
3	0.935	0.936	0.938	0.939	0.941	0.942	0.944	0.945	0.946
4	0.817	0.822	0.825	0.829	0.833	0.837	0.841	0.844	0.848
5	0.976	0.977	0.977	0.978	0.978	0.979	0.979	0.980	0.980
6	0.673	0.679	0.686	0.692	0.698	0.704	0.711	0.717	0.722
7	0.598	0.606	0.613	0.621	0.628	0.635	0.642	0.649	0.656
8	0.953	0.954	0.955	0.956	0.957	0.958	0.959	0.960	0.961
9	0.748	0.753	0.759	0.764	0.769	0.774	0.779	0.783	0.788
10	0.801	0.806	0.810	0.814	0.818	0.822	0.826	0.830	0.834
11	0.660	0.667	0.674	0.680	0.687	0.693	0.699	0.705	0.712
mean eff	0.803	0.807	0.811	0.815	0.819	0.823	0.826	0.830	0.834

Model 1 production function (deposits as output)

B: 13-The OLS estimates

	coefficient	standard-error	t-ratio
beta 0	0.20951365E	0.11843684E	0.17689905E
beta 1	0.22446894E	0.64533204E-01	0.34783480E
beta 2	0.63520644E	0.75665742E-01	0.83949014E
beta 3	0.76363855E-01	0.10403435E	0.73402542E
beta 4	0.26051602E	0.12716437E	0.20486558E
sigma-squared 0.58228563E-01			
log likelihood function = 0.28377021E			

B: 14-The final MLE estimates

	coefficient	standard-error	t-ratio
beta 0	0.40097299E	0.10998387E	0.36457437E
beta 1	0.85621624E-01	0.79338143E-01	0.10791987E
beta 2	0.70117422E	0.94245715E-01	0.74398525E
beta 3	0.86706788E-01	0.12534461E	0.69174724E
beta 4	0.22659352E	0.11905943E	0.19031967E
sigma-squared	0.21548496E	0.12188378E	0.17679543E
gamma	0.88208375E	0.76657560E-01	0.11506807E
mu	-0.87195362E	0.53176532E	-0.16397339E
eta	0.68898220E-01	0.24698583E-01	0.27895616E
log likelihood function = 0.27579573E			

B: 15-Technical efficiency estimates

	eff.-est.								
firm	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
1	0.956	0.953	0.950	0.946	0.943	0.939	0.935	0.930	0.925
2	0.942	0.938	0.933	0.929	0.924	0.919	0.914	0.908	0.902
3	0.523	0.499	0.475	0.450	0.426	0.400	0.375	0.350	0.325
4	0.955	0.952	0.949	0.945	0.942	0.938	0.934	0.929	0.924
5	0.980	0.979	0.977	0.976	0.974	0.972	0.971	0.968	0.966
6	0.793	0.780	0.767	0.752	0.737	0.721	0.705	0.688	0.670
7	0.853	0.843	0.833	0.822	0.811	0.799	0.787	0.773	0.759
8	0.959	0.956	0.953	0.950	0.947	0.943	0.939	0.935	0.931
9	0.871	0.863	0.854	0.844	0.834	0.824	0.812	0.801	0.788
10	0.877	0.869	0.861	0.852	0.842	0.832	0.821	0.810	0.798
11	0.849	0.840	0.829	0.818	0.807	0.795	0.782	0.769	0.754
mean eff	0.869	0.861	0.853	0.844	0.835	0.826	0.816	0.806	0.795

Model 1 production function (equity capital as output)

B: 16-The OLS estimates

	coefficient	standard-error	t-ratio
beta 0	0.56940805E	0.21109676E	0.26973794E
beta 1	-0.22337478E-01	0.11502122E	-0.19420311E
beta 2	0.74997297E	0.13486338E	0.55609831E
beta 3	-0.20367497E	0.18542637E	-0.10984143E
beta 4	0.44274954E-01	0.22665232E	0.19534304E
sigma-squared 0.18498033E			
log likelihood function = -0.54378036E			

B: 17-The final MLE estimates

	coefficient	standard-error	t-ratio
beta 0	0.11418259E	0.14136552E	0.80771173E
beta 1	0.28272304E	0.11985362E	0.23589029E
beta 2	0.14813382E	0.11731976E	0.12626503E
beta 3	0.22428845E	0.20028153E	0.11198659E
beta 4	0.11316743E	0.17371520E	0.65145380E
sigma-squared	0.36557236E	0.51363385E-01	0.71173728E
gamma	0.89849082E	0.21722130E-01	0.41362924E
mu	0.11462345E	0.24629771E	0.46538579E
eta	-0.86300895E-01	0.16730536E-01	-0.51582865E
log likelihood function = 0.18038772E			

B: 18-Technical efficiency estimates

	eff.-est.								
firm	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
1	0.233	0.263	0.294	0.325	0.356	0.388	0.420	0.451	0.482
2	0.139E	0.163	0.190	0.218	0.247	0.277	0.308	0.339	0.371
3	0.891	0.900	0.907	0.915	0.921	0.927	0.933	0.938	0.943
4	0.278	0.309	0.340	0.372	0.404	0.435	0.466	0.496	0.526
5	0.359	0.391	0.422	0.453	0.484	0.514	0.543	0.571	0.598
6	0.208	0.237	0.267	0.297	0.329	0.360	0.392	0.424	0.455
7	0.132	0.156	0.182	0.209	0.238	0.268	0.299	0.330	0.362
8	0.356	0.388	0.419	0.450	0.481	0.511	0.540	0.568	0.595
9	0.182	0.210	0.239	0.269	0.300	0.331	0.363	0.394	0.426
10	0.343	0.375	0.406	0.438	0.469	0.499	0.528	0.557	0.584
11	0.291	0.322	0.353	0.385	0.417	0.448	0.479	0.509	0.538
mean eff	0.310	0.337	0.365	0.394	0.422	0.451	0.479	0.507	0.534

Table 27: The results of BCC model (See file BCC)
Table 28: The results of CCR model (See file CCR)