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Measurement of Efficiency in Greek Banking Industries in The Light of the Financial Crisis

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Abstract:

The main purpose of the present paper is to investigate the impact of the global financial crisis on the efficiency of Greek banks during the period 2008-2010. The DEA model is applied according to input oriented approach in order to measure the technical and the scale efficiency scores of 20 Greek banks. Generally, the results indicate that the global financial crisis did not affect adversely the efficiency of Greek banks during the examined period. The findings suggest a slight increase in technical and scale efficiency scores in 2009 and a decline in technical and scale efficiency scores in 2010.

Key Words: *Technical efficiency, scale efficiency, data envelopment analysis, input oriented model.*

JEL Classification :

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1. Introduction

The efficiency of European banks has been one of the major topics in monetary and financial environment. The financial integration, the greater deregulation and the technological change of the European banking system forced financial institutions to strive for greater operational efficiency (Liapis *et al.,* 2013). The enhanced competition due to the globalization of the banking system, the expansion of ATM's and e-banking (Pasiouras, 2006) has encouraged banks to improve the efficiency of their operations. However, the collapse of Lehman Brothers led to a global financial crisis that affected the real economy in Europe. The global financial crisis affected adversely the European banks that forced to minimize operational inefficiencies.

To the best of our knowledge, the purpose of this study is to investigate the impact of the global financial crisis on the efficiency of Greek banks during the period 2008-2010. Although there is a well established literature on measurement of European banking efficiency a few studies are focused on the impact of global financial crisis on banking efficiency. This paper contributes to previous work and applies a DEA model in order to extract technical and scale efficiency scores of 20 Greek banking institutions for three years and find answers to the following concerns. How efficient are Greek banks? How the efficiency of Greek banks changed due to the global financial crisis? How the global financial crisis affected technical and scale efficiency of Greek banks?

The remainder of this study is organized below as following. Chapter 2 analyses the concepts of efficiency and Chapter 3 reviews major studies in literature about efficiency in Greek banking sector. Chapter 4 presents the existing methodology and Chapter 5 concludes the data collected for three years. Chapter 6 indicates the empirical results for three years and Chapter 7 sums up the major conclusions of the study.

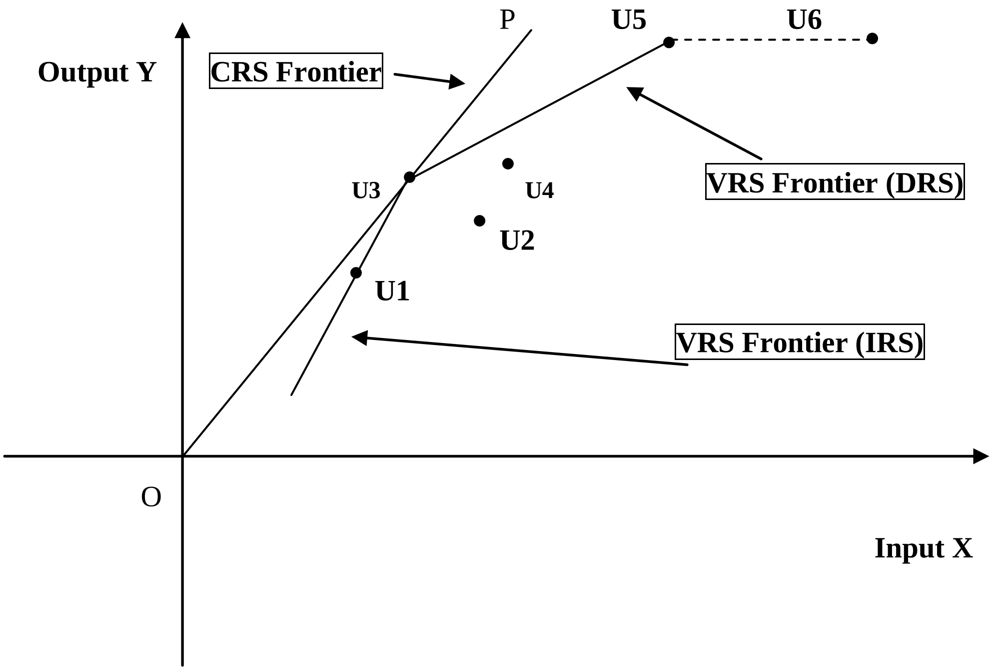
2. Conceptual Framework

Farrell (1957) proposed two components in order to define efficiency. The first component is technical efficiency and the second is allocative efficiency. First of all, technical efficiency reflects the ability of a DMU to minimize inputs in order to produce a given level of outputs. Allocative efficiency reflects the ability of a DMU to use inputs in optimal proportions given their respective prices and production technology. It is worth mentioning that the level of efficiency of the individual firm is the ratio of total weighted outputs to total weighted inputs. The decision making unit (DMU) is the entity (business, regional, sector, country) that transforms n inputs into m outputs based on a specific technology.

Coelli *et al.* (1997) define total efficiency measures as the product of technical efficiency and allocative efficiency. Efficiency ratio ranges between zero and one. An efficiency score of one denotes a fully efficient DMU while any other deviation from one indicates inefficiency. For example, an efficiency score measured against a cost frontier of 80% indicates that the DMU could have reduced cost by 20% without altering its output vector. (Brack and Jimborean, 2009)

Figure 1 indicates that DMU_1, DMU_3, DMU_5 are efficient as they lie on the efficient part of the production frontier. Particularly, DMU_3 is efficient under CRS and $DMU_{1,}$ DMU_5 are efficient under VRS. Essentially, DMU_1 operates under increasing returns to scale (IRS) and is subject to economies of scale while DMU_5 operates under decreasing returns to scale (DRS) and is subject to diseconomies of scale. On the other hand, DMU_2 and DMU_4 lie inside the production frontier and they are inefficient while DMU_6 is inefficient although it lies on the frontier as the same amounts of outputs can be clearly produced with less input. (Webb, 2003, Brack and Jimborean, 2009).

Figure 1: The DEA Production Frontier (Webb, 2003)



The non-parametric approach, specifically the DEA model, measure scale efficiency by estimating two technical efficiency scores under the assumptions of CRS[2] and VRS[3]. As a result, the scale efficiency is obtained by dividing the technical efficiency under CRS to technical efficiency under VRS.

$$Scale\ Efficiency = \frac{TE_{CRS}}{TE_{VRS}}\ (Coelli, 1996a) \Rightarrow TE_{CRS} = TE_{VRS}\ .\ SE$$

3. A Brief Review of Literature

Alzubaidi and Bougheas (2012), investigate banking efficiency across 15 EU countries during the period 2005-2010. The efficiency is measured according to DEA model for 255 banks of varying asset sizes. The purpose of this study is to examine whether the financial crisis has affected the efficiency of European banks and compare the efficiency scores of the pre-crisis two years period 2005-2006 with the efficiency scores of the post-crisis two year period 2009-2010. The inputs were total deposits, fixed assets, operating expenses and loans loss provisions' while the outputs were total loans, other earning assets and total other income. The results show a fall in the efficiency scores, approximately 12%, during the examined period. The financial crisis has a differential impact on the efficiency scores of European countries as the biggest drop is observed in Belgian and Danish banks followed by Irish, Greek, Finnish and Dutch banks. Finally, the biggest drop in efficiency scores is observed in commercial banks followed by saving banks, real estate and cooperative banks.

Aggelopoulos, Georgopoulos and Siriopoulos (2010), investigate production and profit efficiency in the operation of homogenous branches of a large Greek private

[2] Charnes, Cooper and Rhobes (1978) propose a model with input oriented approach assuming constant returns to scale. Under this assumption firms operate at an optimal scale. For example, a unit percent increase in inputs leads to a unit percent increase in outputs. There is a proportional relationship between inputs and outputs

[3] Banker, Charnes and Cooper (1984) propose an extension to constant returns to scale (CRS) model, a variable returns to scale model (VRS). The CCR model is appropriate when we cannot make behavioral assumptions of DMUs objectives like cost minimization and profit maximization aspects of production. The BCC model is used when firms price and cost information are available in order to specify the objective functions.

bank before and during the global financial crisis. The non-parametric approach DEA model is applied according to input oriented method during the period 2007-2009 when the financial crisis affected Greek's bank efficiency. For the purpose of this study data is collected for the branch network of 27 branches of a major commercial private bank. The results indicate that the average pure technical efficiency both in two dimensions decreased during the turmoil period and mostly for the average profit efficiency. Particularly, the average technical efficiency for production efficiency was 90,55% before the crisis and became 89,09% in the period of financial crisis. However, the reduction is more intense for the profit efficiency when the average efficiency was 89,09% before the crisis and became 84,14% during the financial crisis.

Varias and Sofianopoulou (2012) evaluate the efficiency of the 19 biggest Greek commercial banks in the financial year 2009. This year was chosen as it was very crucial for the Greek economy and the Greek financial system. Particularly, the global financial crisis has affected the real economy and the Greek banking system had to face a radical recession. For the purpose of this study the DEA model is applied by using three inputs and three outputs according to intermediation approach. The results indicate that 31,58% of the Greek banking system operate efficiently. The rest of the commercial banks were relatively inefficient as 68,42% of the banking sector operate inefficiently. As a result, the global financial crisis affected adversely the efficiency scores of the 19 Greek biggest banks.

Kuchler (2013) investigates the relative efficiency of all Danish banks over the period 2001-2012. The efficiency scores were measured according to DEA and SPF models between the three different sub-periods. Particularly the efficiency was evaluated during the recession period 2008-2010 that was affected by the global financial crisis. For the purpose of this study three inputs and five outputs were collected in order to analyze the development in relative efficiency scores over time. The main findings suggest that the relative efficiency scores of the Danish banks increased during the expansion period 2003-2007 and decreased during the recession period 2008-2010. However, in the recent years 2010-2012 was observed an increase in the efficiency scores as a result of adjustment of inputs to reduced outputs and a general consolidation in the banking sector.

Georgantopoulos and Tsamis (2013) assess the efficiency in the Greek banking sector during the period of global financial crisis 2007-2011. Thalassinos *et al.* (2014) and Thalassinos (2014) have analyzed sovereign debt with respect to CDS spreads. Thalassinos, Liapis and Thalassinos (2011) have analyzed the efficiency of the Greek banking system during the financial crisis. The efficiency analysis of Greek commercial banks during the financial crisis was performed in conjunction with financial analysis. Particularly, ROA and NIM[4] were used as dependent variables and asset size, asset utilization and efficiency ratio were employed as the predictors of banking efficiency. The dependent variables that selected in this study were measures of the selected banks financial performance. These ratios are reliable proxy of banking efficiency and profitability. For the purpose of this study 7 Greek commercial banks were selected and an empirical research is employed in order to estimate the impact of independent variables on financial performance indicators. The main findings show that large banks underperform compared to small banks. The financial crisis affected adversely ROE[5], ROD[6] and ROA[7] for the selected Greek commercial banks especially for the year 2011. As a result, the financial crisis deteriorated the financial performance and the efficiency level of Greek banking institutions. Finally, the regression analysis results indicate significant correlation between efficiency indicators and independent variables.

Brissimis, Delis and Tsionas (2006), estimate technical and allocative efficiency in a sample of European banks during the period 1996-2003. A cross country comparison of the efficiency level of European banks has been investigated by modeling both technical and allocative efficiency of European banks. For the purpose of this study a cross sectional maximum likelihood estimation method is applied in a panel data of European banks from 13 European Union countries. The results suggest that European banks are characterized by constant returns to scale although the estimation methods tend to underestimate scale efficiencies. Moreover, technical and allocative efficiency results tend to be high. The most technically efficient banking sectors were those of Austria, Germany and UK while the banking sectors of Ireland, Portugal and Italy seem to be inefficient. Generally the results indicate on average that European banks exhibit CRS while technical and allocative efficiency were close to 80% and 75% respectively. The overall economic efficiency shows an improving trend during the examined period of analysis.

[4] NIM: Net Interest Margin: It is the ratio of Net Revenues from Interest bearing activities to Average Earning Assets

[5] ROE: Return on Equity: it is the ratio of Net Income to Shareholders' equity

[6] ROD: Return on Deposits: it is the ratio of Net Profits to Total Deposits

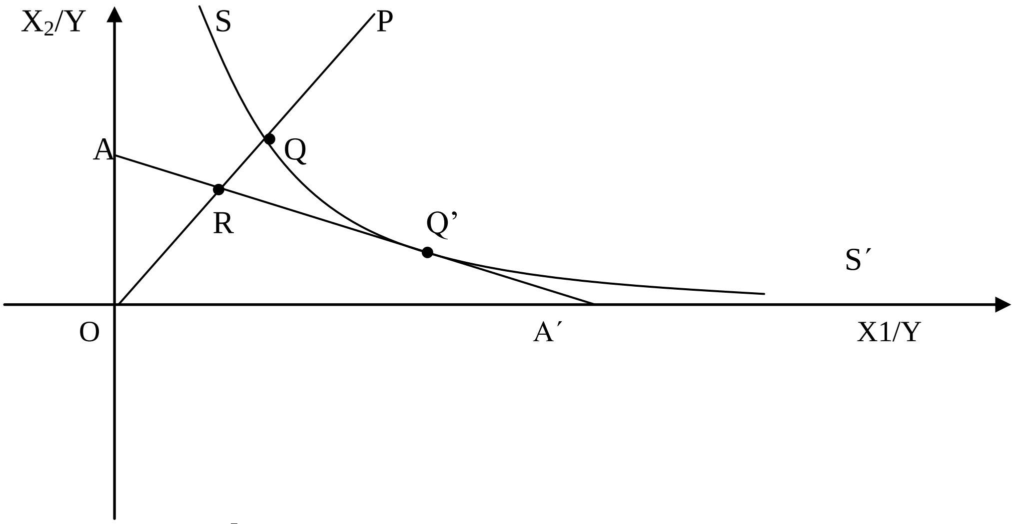
[7] ROA: Return on Assets: it is the ratio of Net Income after Taxes to Total Assets

4. Methodological Frameworks

4.1 Input Oriented Model

Farrell (1957) uses two inputs (x_1,x_2) in order to produce a single output (y) under the assumption of constant returns to scale. It is worth mentioning that this assumption is in line with technology by using a unit isoquant. The concepts of technical efficiency, allocative efficiency and overall economic efficiency under the input oriented approach are defined in the figure 2 below. (Floros and Giordani, 2008)

Figure 2: The input oriented model (Coelli, 1997)



The isoquant SS' depicts a fully efficient firm and measures the technical efficiency. The line OP represents the quantities of inputs that a firm uses in order to produce a unit of output. The technical inefficiency is represented by the distance QP . This is the amount of the inputs that could be reduced by producing the same amounts of outputs. So the ratio $\frac{QP}{OP}$ represents the percentage that inputs could be reduced. The technical efficiency is defined as the ratio $TE = \frac{OQ}{OP}$ or $TE = 1 - \frac{QP}{OP}$.

The value of one indicates a fully technical efficient firm while a value different from one indicates firms' inefficiency. (Floros & Giordani, 2008)

The line AA' shows the input price rate and is also known as allocative efficiency. The point Q represents the technical but allocative inefficient point and point Q' indicates the technical and allocative efficient point. As a result, allocative efficiency is equal to $AE = \frac{OR}{OQ}.\ RQ$ and shows the production cost that should be reduced in order to occur at the allocative efficient point Q'. If we take into account technical and allocative efficiency we are going to retrieve total economic efficiency.

$EE = \frac{OR}{OP}.RP$: the distance where there is a reduction in the cost.

$$EE = TE.AE = \frac{OQ}{OP}.\frac{OR}{OQ} = \frac{OR}{OP}$$ (Floros and Giordani, 2008)

4.2 Data Envelopment Analysis

Charnes et al. (1978) introduced a non-parametric approach, DEA model, in order to measure the relative efficiency of a DMU compared to efficient units. DEA model is receiving increasing attention and is widely used as a tool for evaluating and improving the performance of manufacturing and service operations. It is a multi-factor productivity analysis model for measuring relative efficiency of a homogenous set of DMUs. The efficiency score is defined as following. (Talluri, 2000)

$$Efficiency = \frac{Weighted\ Sum\ of\ Outputs}{Weighted\ Sum\ of\ Inputs} \quad (1) \quad \textbf{(Talluri, 2000)}$$

Golany points out that DEA model is receiving great attention for efficiency evaluation as many research papers published and number of applications performed to real world problems. It is worth mentioning that this technique was firstly used by Sherman and Gold in banking efficiency context. According to the concept of efficiency defined above, DEA model calculates efficiency by estimating a production frontier that represents the highest values of outputs/benefits that could be generated by a given set of inputs/resources. (Vassiloglou and Giokas, 1990).
Halkos and Salamouris state that the "fundamental feature of DEA is that technical efficiency scores depend on the performance of the sample of inputs and outputs. As

a result, DEA model produces relative rather than absolute measures of technical efficiency scores for each DMU". (Halkos and Salamouris, 2004)

Under the assumption that there are n DMU each with m inputs and s outputs then the relative efficiency score of a test DMU p is received by solving the following model proposed by Charnes et al. (1978).

$$\max \frac{\sum_{k=1}^{s} v_k\, y_{kp}}{\sum_{j=1}^{m} u_j\, x_{jp}}, \quad st \quad \frac{\sum_{k=1}^{s} v_k\, y_{ki}}{\sum_{j=1}^{m} u_j\, x_{ji}} \leq 1 \;\forall\, i, \quad v_k, u_j \geq 0 \quad \forall\, k, j \qquad \textbf{(2)}$$

y_{kp}: amount of output k produced by DMU p,

v_k: weighted given to output k

u_j: weighted given to input j

x_{jp}: amount of input j utilized by DMU p

The fractional program can be converted to linear program as following:

$$\max \sum_{k=1}^{s} v_k\, y_{kp}$$

$$st \sum_{j=1}^{m} u_j\, x_{jp} = 1, \qquad \sum_{k=1}^{s} v_k\, y_{ki} - \sum_{j=1}^{m} u_j\, x_{ji} \leq 0 \;\forall\, i$$

$$v_k, u_j \geq 0 \quad \forall\, k, j \qquad \textbf{(3)}$$

The above problem is run n times in order to identify the relative efficiency scores of all DMUs. Each DMU selects the inputs and outputs weights that maximize its relative efficiency scores. A DMU that obtains a score of one is considered to be efficient while a DMU that obtains a score less than one is considered to be inefficient. (Talluri, 2000)

5. Data and Variables

The data of this study is collected from Bankscope database during the period 2008-2010 for 20 Greek banks. These Greek banks are the following: National Bank, ATE Bank, Piraeus Bank, Alpha Bank, Eurobank Ergasias, Emporiki Bank, Hellenic Post Bank, Marfin Egnatia Bank, Cyprus Bank, Hellenic Bank Group, Probank, FBB Bank, Geniki Bank Societe Generale, T-Bank, Millennium Bank, Proton Bank, Pancretan Cooperative Bank, Panellinia Bank, Attica Bank and Investment Bank of Greece.
The technical and scale efficiency scores are calculated according to input oriented approach by using three inputs and two outputs[8]. The results are calculated according to the assumptions of CRS and VRS models. The inputs are: total deposits from customers, total capital and number of employees. The outputs are: total income and loans and requirements from customers.

6. Empirical Results

6.1. Results of efficiency analysis

The results are measured according to Data Envelopment analysis model for 20 Greek banking industries for three years and are presented in the following tables. The results have been obtained by applying the DEAFrontier Free Trial Version owned by Joe Zhu.

[8] The intermediation approach of Sealey and Lindley (1977) is used in order to specify the inputs-outputs. This approach considers Greek banks as financial intermediaries that collect deposits from customers and transform them into loans granted to borrowers.

Table 1: Technical -Scale Efficiency Scores during 2008-2010

YEARS													
		2008				2009				2010			
DMUS	DMU NAME	CRS Efficiency	VRS Efficiency	SCALE Efficiency	RTS	CRS Efficiency	VRS Efficiency	SCALE Efficiency	RTS	CRS Efficiency	VRS Efficiency	SCALE Efficiency	RTS
1	NBG	1	1	1	Constant	1	1	1	Constant	1	1	1	Constant
2	ATE Bank	1	1	1	Constant	1	1	1	Constant	0,64	0,65	0,99	Increasing
3	Piraeus Bank S.A.	0,94	1	0,94	Decreasing	1	1	1	Constant	0,76	0,80	0,94	Decreasing
4	Alpha Bank S.A	1	1	1	Constant	0,99	1	0,99	Decreasing	1	1	1	Constant
5	Eurobank Ergasias	0,82	0,93	0,88	Decreasing	0,56	0,57	0,97	Increasing	0,12	0,26	0,48	Increasing
6	Emporiki	0,93	1	0,93	Decreasing	1	1	1	Constant	1	1	1	Constant
7	Hellenic Post-Bank	0,10	0,18	0,56	Increasing	0,51	0,52	0,99	Decreasing	0,54	0,57	0,94	Increasing
8	Marfin Egnatia	1	1	1	Constant	0,72	0,79	0,91	Decreasing	0,91	0,91	0,99	Increasing
9	Cyprus Bank	1	1	1	Constant	1	1	1	Constant	1	1	1	Constant
10	Hellenic Bank Group	0,71	0,72	0,98	Increasing	1	1	1	Constant	0,66	0,69	0,95	Increasing
11	Probank	0,75	0,81	0,93	Increasing	0,82	0,85	0,96	Increasing	0,68	0,75	0,90	Increasing
12	FBB-Bank	1	1	1	Constant	0,85	1	0,85	Increasing	0,89	1	0,89	Increasing
13	Geniki Bank Soci. Generale	0,09	0,24	0,38	Increasing	0,66	0,68	0,96	Increasing	1	1	1	Constant
14	T-Bank S.A.	1	1	1	Constant	0,53	1	0,53	Increasing	0,53	0,86	0,61	Increasing
15	Millennium	1	1	1	Constant	1	1	1	Constant	1	1	1	Constant
16	Proton Bank S.A.	0,71	0,82	0,86	Increasing	0,98	0,98	0,99	Increasing	0,78	0,79	0,99	Decreasing
17	Pancretan Couperative Bank	1	1	1	Constant	0,76	0,85	0,90	Increasing	0,86	0,98	0,87	Increasing
18	Panellinia Bank S.A.	0,78	1	0,78	Increasing	0,76	1	0,76	Increasing	0,75	1	0,75	Increasing
19	Attica bank	0,85	0,87	0,97	Increasing	0,65	0,70	0,93	Increasing	0,76	0,78	0,98	Increasing
20	Investment Bank of Greece	1	1	1	Constant	1	1	1	Constant	1	1	1	Constant

Table 2: Descriptive statistics of results

	YEARS								
	2008			2009			2010		
Descriptive Statistics	TE_{CRS}	TE_{VRS}	SE	TE_{CRS}	TE_{VRS}	SE	TE_{CRS}	TE_{VRS}	SE
MIN	0,0938	0,1870	0,3837	0,5188	0,5228	0,5389	0,1292	0,2654	0,4868
MAX	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000
Average Scores	0,8366	0,8801	0,9130	0,8432	0,8981	0,9411	0,7973	0,8545	0,9174
St.Deviation	0,2728	0,2412	0,1631	0,1791	0,1584	0,1128	0,2238	0,1952	0,1413

According to table 2 the average technical and scale efficiency scores increased in 2009 and decreased in 2010. Although the global financial crisis has affected adversely the real economy and the banking institutions in Europe, we observe that the Greek banking system remains stable and unaffected by the global financial crisis in 2009 as the efficiency scores are increased. This improvement in efficiency scores is depended on a number of efficiency determinants like the capital base of banks, the profitability, the liquidity risk, the credit risk, the market value and etc. According to Gortsos (2011), the global financial crisis did not affect the Greek banking system as Greek banks were not exposed to toxic bonds. The strong capital base of Greek banks, the prudential supervision by the Bank of Greece and the measures taken by the European Central Bank in order to enhance Greek bank's liquidity lead to a healthy and strong capitalized banking system.

However, the year 2010 indicates a decrease in technical and scale efficiency scores of Greek banks. The global financial crisis affected adversely the technical and the scale efficiency of Greek banking institutions due to followings reasons. First of all, a decline in Greek banks' deposits, a deteriorate in banks' profitability and an increase in Non-performing loans are observed in 2010. Particularly, the Non-performing loans increased from 7,7% in 2009 to 10% on September 2010. The credit risk of Greek banking institutions increased as the probability of default increased as well. The problem of liquidity due to decrease in banks' deposits create a climate of insecurity for depositors and investors concerning the viability of the Greek banking system. Finally, Greek banks had limited access to interbank money market and debt capital market. All these factors are led to the decrease in the efficiency scores of Greek banks.

6.2. The Change of Efficiency During the Global Financial Crisis

The average technical efficiency scores of this study range between 0,79 and 0,84 under CRS and 0,85 to 0,90 under VRS. The empirical results show that the overall mean level of technical efficiency scores are 0,82 and 0,88 for CRS and VRS respectively. The results suggest that Greek banks could have reduced their inputs by 18% under CRS and 12% under VRS with the existing level of outputs.

This high technical efficiency scores are in line with the results of other studies that investigate Greek banking efficiency during the pre-crisis period such as:

- Tsionas, Lolos and Christopoulos (2001) estimate technical efficiency, TFP change and technical change of the Greek banking system over the period 1993-1998. The results show that the majority of Greek banks operate at a high technical efficiency level of over 95%.
- Christopoulos & Tsionas (2001) estimate efficiency in the Greek commercial banking sector over the period 1993-1998. The results show average technical efficiency scores of about 80% and 83% respectively.
- Halkos and Salamouris (2004) estimate efficiency of Greek banks over the period 1997-1999. The results suggest quite high mean efficiency scores that range between 0,91 and 0,95.
- Rezitis (2004), investigates productivity growth and technical efficiency in the Greek banking sector over the period 1982-1997. The results show an average level of technical efficiency about 91,3% during the examined period.
- Pasiouras (2006), uses DEA model to investigate the efficiency of the Greek commercial banking sector during 2000-2004. The results, provide quite high technical efficiency scores that range between 0,977 for 2000 and 0,882 for 2004 with the overall mean efficiency over the period equal to 0,95.
- Floros & Giordani (2008), estimate Greek banking efficiency during the period 2004-2005. The results suggest quite high technical efficiency scores that range between 71% for 2004 and 73,6% for 2005.
- Spathis, Kosmidou and Doumpos (2001), investigate differences in profitability and efficiency between small and large banks during the period 1990-1999. The results suggest, high technical efficiency scores according the two methodologies used, equal to 86,71% and 83,35% respectively.
- Gaganis and Pasiouras (2009), measure Greek banking efficiency during the period 1999-2004. The results suggest that average pure technical efficiency is equal to 0,7325 and average scale efficiency is equal to 0,6830.
- Brissimis, Delis ans Tsionas (2006), estimate technical and allocative efficiency in a sample of European banks during the period 1996-2003. The results indicate quite high technical and allocative efficiency scores equal to 80% and 75% respectively. As a result, the trend for Greek banks is to exhibit quite high technical and allocative efficiency scores during the examined period.

The high technical efficiency scores of this paper are not in line with the study of Alzubaidi and Bougheas (2012). This study investigates the efficiency scores across 15 EU countries during the period 2005-2010. The results indicate low average efficiency scores equal to 0,56 for Greek banks during the examined period.
The results of this study are compared with the results of past studies of a pre-crisis period in order to investigate the impact of financial crisis on the efficiency of Greek banks. The main result of this study is that the financial crisis did not affect adversely the efficiency of Greek banks as there is trend of high technical and scale efficiency scores during the period 2008-2010. Finally, Greek banks remain healthy and achieve at least the same and higher efficiency scores compared to the pre-crisis period.

6.3. Frequency Distribution Tables

The results of the DEA model for the 20 Greek banks are analyzed in the following frequency distribution tables. Greek banks are classified according to technical and scale efficiency intervals.

Generally speaking, most of the Greek banks achieve quite high technical efficiency scores as they are classified in the technical efficiency interval 0,9-1. It is worth mentioning that 60%, 50% and 40% of Greek banks are classified in the technical efficiency interval 0,9-1 during the period 2008-2010 under the assumptions of CRS. Similarly, 70% and 65% of Greek banks are classified in the technical efficiency interval 0,9-1, during the period 2008-2009 under the assumptions of VRS.

Furthermore, 55% of Greek banks are classified in the technical efficiency interval 0,9-1 in year 2010 under the assumptions of VRS. Particularly, under the assumptions of VRS model technical efficiency scores are higher as more banks are classified in the technical efficiency interval 0,9-1. Finally, the year 2010 reveals lower technical efficiency scores compared to other years as fewer banks are classified in the technical efficiency interval 0,9-1.

Table 3: Frequency Distribution Table

RTS									
	CRS			VRS			CRS/VRS		
	YEARS			YEARS			YEARS		
	2008	2009	2010	2008	2009	2010	2008	2009	2010
Technical efficiency Intervals	Frequency	Frequency	Frequency	Frequency	Frequency	Frequency	Frequency	Frequency	Frequency
0-0,1	1	0	0	0	0	0	0	0	0
0,1-0,2	1	0	1	1	0	0	0	0	0
0,2-0,3	0	0	0	1	0	1	0	0	0
0,3-0,4	0	0	0	0	0	0	1	0	0
0,4-0,5	0	0	0	0	0	0	0	0	1
0,5-0,6	0	3	2	0	2	1	1	1	0
0,6-0,7	0	2	3	0	1	2	0	0	1
0,7-0,8	5	3	4	1	2	3	1	1	1
0,8-0,9	1	2	2	3	2	2	2	1	2
0,9-1	**12**	**10**	**8**	**14**	**13**	**11**	**15**	**17**	**15**

6.4. Technical and Scale Efficiency of Banks According to Returns to Scale

In this section of analysis we classify the average technical and scale efficiency scores of banks according to increasing returns to scale (IRS), decreasing returns to scale (DRS) and constant returns to scale (CRS). The returns to scale are available only under the assumptions of CRS according to DEAFrontier Free Trial Version.

Before we classify the banks according to returns to scale it is necessary to analyze the concepts of IRS, DRS and CRS. First of all, the term return to scale arises in the context of production function. It is obviously a change in outputs resulting from a proportional change in inputs. Particularly, when outputs increases in the proportional change of inputs then CRS occurs. If outputs increase more than a proportional change of inputs then IRS occurs. If outputs increase less than the proportional change of inputs then DRS occurs. In the following table 4, we present the average technical and scale efficiency scores for 20 Greek banking institutions according to CRS, IRS and DRS.

Table 4: Average technical and scale efficiency according to RTS

Year	2008			2009			2010		
Returns to Scale	**Banks**	**Average SE**	**Average TE**	**Banks**	**Average SE**	**Average TE**	**Banks**	**Average SE**	**Average TE**
Supra-optimal Scale (DRS)	3	0,92	0,90	3	0,96	0,74	2	0,97	0,77
Optimal Scale (CRS)	10	1,00	1,00	8	1,00	1,00	7	1,00	1,00
Suboptimal Scale (IRS)	7	0,78	0,57	9	0,87	0,73	11	0,85	0,67
MAX		1,00	1,00		1,00	1,00		1,00	1,00
MIN		0,78	0,57		0,87	0,73		0,85	0,67
St. deviation		0,10	0,22		0,06	0,14		0,07	0,16

The results are classified according to returns to scale for three years. The DEA model provides results for returns to scale only under the assumptions of CRS. First of all, in the year 2008 it is obtained that ten banks are subject to CRS, seven banks are subject to IRS and three banks are subject to DRS. The average technical efficiency scores are equal to 1, 0,57 and 0,90 respectively. Secondly, in the year 2009 it is derived that eight banks exhibits CRS, nine banks exhibits IRS with average technical efficiency score equals to 0,73 and three banks exhibits DRS with average technical efficiency score equals to 0,74. Most of banks are categorized under IRS, CRS and DRS during the period 2008-2010. Finally, in the year 2010 it is indicated that seven banks are classified according to CRS with average technical efficiency score equals to one. However, eleven banks are subject to IRS with average technical efficiency score equals to 0,672. Finally, two banks are subject to DRS with average technical efficiency score equals to 0,77. It is observed that most banks are classified under IRS, CRS and DRS.

It is worth mentioning that banks which are classified under the assumptions of CRS present to have a technical efficiency score equals to one. This occurs due to same proportional change of inputs and outputs. The average technical efficiency scores of banks with IRS is lower than the average technical efficiency scores of banks with DRS during the examined period 2008-2010. According to table 4, the average technical and scale efficiency scores are calculated for the period 2008-2010 and are classified to supra-optimal scale, to optimal scale and suboptimal scale. Descriptive statistics are also provided.

First of all, banks with suboptimal scale achieve on average lower scale efficiency scores than banks with supra-optimal scale. This gap tends to decrease in the years 2009 and 2010. Thus, these banks could have adjusted their output levels to a greater extent than banks with supra-optimal scale. Secondly, banks with optimal scale achieve higher technical and scale efficiency scores than banks with non optimal scale. Thirdly, banks with suboptimal scale achieve lower technical efficiency scores than banks with supra-optimal scale. However, during the years 2009-2010 this gap tended to narrow compared to 2008. Finally, the results concerning this part of analysis are in line with the results obtained by Karagiannis and Sarris (2005).

The results in table 4 also reveal that the majority of Greek banks, is subject to suboptimal scale except for the year 2008. In fact, in the year 2008, it is indicated that most of the Greek banks exhibit optimal scale and average technical and scale efficiency scores equal to one. On the other hand, in the year 2009 it is observed that the majority of banks (9) operate under suboptimal scale and the average technical efficiency scores are lower than average scale efficiency scores. Particularly, the average technical and scale efficiency scores are equal to 0,73 and 0,88 respectively. In the last year, 2010, it is concluded that most of the banks (11) operate under suboptimal scale and average technical efficiency scores are lower than average scale efficiency scores. The results under supra-optimal scale for the period 2008-2010 indicate that average technical efficiency scores are lower than average scale efficiency scores.

The former findings seem to confirm Karagiannis and Sarris (2005) results that state: “the degree of technical efficiency was found to be lower than the degree of scale efficiency and thus a greater proportion of overall efficiency is due to producing below the production frontier than to operating at an inefficient scale"(Karagiannis and Sarris, 2005, p. 449).

7. Conclusion

This study investigates technical and scale efficiency scores of 20 Greek banking industries during the recession period 2008-2010. A non-parametric approach, Data Envelopment Analysis (DEA) was applied under the assumptions of CRS and VRS models. The objective of this study is twofold: (i) to investigate the effect of the global financial crisis on Greek banks' efficiency (ii) to calculate technical and scale efficiency scores of 20 Greek banking industries by using the non-parametric approach.

The general impression from the reported empirical results is that the global financial crisis did not affect adversely the efficiency scores of Greek banks. The empirical results show that technical and scale efficiency scores increased in 2009 and decreased in 2010. These technical and scale efficiency scores of Greek banks in 2009 reveal a Greek banking system with a strong capital base and low liquidity risk. Finally, the impact of global financial crisis is visible in 2010 as Greek banking efficiency declined during this year. Overall, the efficiency scores of Greek banks remain at a high level during the examined period.

The limitations that should be acknowledged and addressed at this study are the following. First of all, the most obvious limitation concerns the constraints on the sample that depicts a very small proportion of the entire population. Secondly, the number of years that banking efficiency is measured are limited (only three years). Thirdly, only one model (DEA) is used to measure efficiency. It is useful a research to be done in order to measure efficiency scores according to parametric and other non-parametric methods. Finally, data for Greek cooperative banks except for Pancretan Cooperative Bank is not available in Bankscope database Bureau Van Dijk. As a result, in this study data is collected from eighteen commercial banks one investment bank and only one cooperative bank.

This paper can be expanded in a future research in order to proceed in a more detailed analysis of banking efficiency. A larger sample of European banks can be derived for a longer period of time in order technical and scale efficiency scores according to DEA model to be measured. Furthermore it is crucial to investigate the determinants of banking efficiency (run a regression model) and concludes which factors affect more the technical efficiency of banks. This would allow more detailed information and comparisons about banks' efficiency.

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