Banking Efficiency, Risk and Stock Performance in the European Union Banking System: the Effect of the World Financial Crisis

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Abstract

This thesis has three main objectives; first, it assesses and evaluates cost and profit efficiencies of the European Union banking system by employing the stochastic frontier analysis (SFA) over the period 2004-2010. It divides the EU region into four groups; the entire EU region, the old and the new EU countries as well as the GIIPS countries. Second, this study investigates the determinants of bank cost and profit inefficiencies with the focus mainly being on the role of banking risks and the world financial crisis (2007-2009) in affecting banking efficiency. Third, this thesis evaluates the impact of different variables on bank stock returns, with the emphasis on bank efficiency, risk and the world financial crisis, over the period 2004-2010.

The empirical findings show that commercial banks in the EU improve their cost and profit efficiencies on average between 2004 and 2010. Also, banks in the old EU countries appear to be more cost efficient but less profit efficient compared to banks in the new EU countries. Interestingly, the empirical analysis concludes that overall insolvency, credit and liquidity risks have significant and positive effects on bank cost and profit inefficiencies during the world financial crisis, suggesting that banks that maintain less risk outperform their counterparts during crisis time. The world financial crisis appears to affect negatively both cost and profit efficiencies of EU banks; however, it has stronger negative effect on banks in the old EU member states than in the new EU countries. Finally, the results show that changes in cost and profit efficiencies along with capital and size variables appear to have a positive and significant influence on bank stock performance in the EU and that bank stock returns are significantly sensitive to market and interest rate risks.

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List of Acronyms

EMU	Economic and Monetary Union
ECB	European Central Bank
EU	European Union
SFA	Stochastic Frontier Analysis
DEA	Data Envelopment Analysis
REM	Random Effects Model
FEM	Fixed Effects Model
IMF	International Monetary Fund
FDH	Free Disposal Hull
DFA	Distribution Free Approach
TFA	Thick Frontier Approach
CAPM	Capital Asset Pricing Model
ROA	Return on Assets
ROE	Return on Equity
CRS	Constant Returns to Scale
VRS	Variable Returns to Scale
TE	Technical Efficiency
AE	Allocative Efficiency
CE	Cost Efficiency
PTE	Pure Technical Efficiency
SE	Scale Efficiency
PE	Profit Efficiency
DMU	Decision Making Unit
EFA	Economic Frontier Approach
ML	Maximum Likelihood
OLS	Ordinary Least Squares
GLS	Generalised Least Squares

VAR	Value-at-Risk
CDO	Collateralised Debt Obligation
MBS	Mortgage-Backed Security
GDP	Gross Domestic Product
SEM	Single European Market
EMS	European Monetary System
EMI	European Monetary Institute
ERM	Exchange Rate Mechanism
M&A	Merger and Acquisition
ECSC	European Coal and Steel Community
EEC	European Economic Community
EAEC	European Atomic Energy Community
EC	European Communities
CEE	Central and Eastern Europe
SEE	South Eastern Europe
CIS	Commonwealth of Independent States
ABS	Asset-Backed Security
LSDV	Least Squares Dummy Variable
MLE	Maximum Likelihood Estimation
ROAA	Return on Average Assets
APT	Arbitrage Pricing Theory
CASR	Cumulative Annual Stock Return
ECM	Error Component Model
BLUE	Best Linear Unbiased Estimator
CLRM	Classical Linear Regression Model
VIF	Variance-Inflation Factor
LM	Lagrange Multiplier

Chapter 1

Background, Objectives, Methodology and Structure of the Study

1.1 Introduction

During the last two decades the integration process has been accelerated in the European banking markets. The multiple forces of financial deregulation, the foundation of the Economic and Monetary Union (EMU) and the introduction of the euro have contributed to that integration. Along with deregulation, the technological change has contributed to the progressive process of integration and increased competition in the banking industry (European Central Bank [ECB], 2010b). Therefore, policy makers and central banks in Europe find it important to study the impact of these changes on banks' performance. The performance in terms of cost reduction or profit maximisation is not the only concern by policy makers and emphasis has been placed on measuring the risk taken to generate acceptable returns within a highly competitive banking environment. The improvement in banking performance also tends to send positive signals to shareholders and investors regarding the future of the bank in which they invest. This in turn highlights the importance of measuring how banks' performance would reflect on banks' stock performance and their wealth maximisation objective. It is expected that banks' managers should aim at improving bank efficiency, controlling risks and maximising shareholders' wealth as long as there is no agency problem.

The financial integration, globalisation, complications of the financial markets and financial innovation are all reasons that have raised concerns about risk in banking systems all around the world. Controlling and monitoring banking risks has been an important issue in recent years because of the negative consequences that risk might bear towards bank performance. Systematic and unsystematic risk might have a significant influence on banking performance and indeed on shareholders' wealth, which as a result should be taken into consideration when analysing banks' performance. The recent global financial crisis (2007-2009) has highlighted the importance of maintaining a sound and healthy banking system by monitoring its performance and risks so as to maintain financial and economic stability. The crisis has deteriorated the performance of banking and financial markets in the US and Europe and other regions across the world.

The banking systems of the European Union (EU) member states; the old and the new states, have faced significant challenges with regard to financial regulations (Casu *et al*., 2006). A) Regarding the old EU countries, the Second European Banking Directive and the single European Passport played a key role in deregulation and eliminating market entry barriers between those countries. This resulted in a higher level of competition and a more unified banking market. The combined effects of the euro introduction, information technology advancement, and the benefitting of new investors from a global capital market fostered the competition and consolidation in the European banking system. B) The new EU countries, on the other hand, underwent major reforms and transformation during the 1990s. They had to move from the centralised planned economic system and mono-banking system towards more liberalised financial and banking systems. The banking sectors in these countries have become more developed due to the flow of foreign capital, market integration, and the establishment of an efficient regulatory framework (Hollo and Nagy, 2006). While the accession of the new EU countries creates more opportunities, it also imposes challenges regarding catching up with the old developed European countries (Mamatzakis *et al*., 2008). The characteristics of the new countries' financial systems indeed differ from the old ones. The new countries depend heavily on bank finance, maintain lower levels of financial intermediation, present higher levels of bank concentration and exhibit higher degrees of foreign involvement in the banking sector than the old EU states (ECB, 2005). The changes in the structure of the economic and financial systems of the EU countries are likely to have significant effects on the performance of banks in this region. So it is interesting to investigate how the integration and unification between the financial systems in all the EU member states have influenced the integration in the banking performance, particularly between the old and the new EU countries.

1.2 Objectives and Motivations

This thesis aims to assess and evaluate the performance of European Union commercial banks in terms of cost and profit efficiencies during the period from 2004 to 2010. This period is of specific importance as it demonstrates a post-transition period for the new EU countries and the effect of unification and integration of the banking and financial systems between the newly joined countries to the EU and the old ones. This represents an interesting case study to analyse and compare between the performance of banking systems of the old and the new EU member states. In particular, unveiling to what extent the banking systems in the two groups (old and new EU countries) are integrated, and how this has influenced the performance of the banks operating in these countries is an interesting issue to study.

This study clusters the EU countries into four groups and examines banks' efficiency in these groups; the entire EU countries (27 countries), the old EU countries (15 countries), the new EU countries (12 countries) and the GIIPS[1] countries (5 countries). We avoid clustering the sample into eurozone and non-eurozone countries as such comparison is out of the scope of this thesis. The influence of risk factors and the global financial crisis (2007-2009) as well as other variables on the EU banking efficiency are also investigated in this study. The study further evaluates the impact of banks' efficiency, risk and other variables on banks' stock returns over the period 2004-2010. The main research questions of this study can be summarised as follows:

1- How do cost and profit efficiency levels of the EU banking system change during the period 2004-2010?
2- How do bank risks and other environmental variables affect bank cost and profit inefficiencies?
3- Do variations in banking efficiency and risks explain variations in the EU bank stock returns over the period from 2004 to 2010?

The contribution of this study to the literature is four-fold. *First*, to the best of the author's knowledge, this is the first study to cover bank cost and profit efficiencies for

[1] GIIPS refers to five EU countries that have faced sovereign-debt crisis; Greece, Ireland, Italy, Portugal and Spain.

the entire EU that includes 27 countries while dividing this sample into four groups; the entire EU, the old EU countries, the new EU countries and the GIIPS countries, and making comparisons between these groups. This comparison takes place in the period that follows the joining of ten countries to the EU in 2004 after they experienced financial transition process. This allows investigation into whether such countries experience deterioration in their banking efficiency as the pressure of meeting the criteria for joining the EU is relieved after that year. We investigate both cost and profit efficiencies because cost efficiency alone might not provide a full picture regarding bank's management performance in competitive markets. Some studies, such as Altunbas *et al*. (2001) and Maudos *et al.* (2002a), argue that the ongoing deregulation and increased competition from non-bank financial intermediaries postulates not only improving cost efficiency but also profit efficiency. However, improving efficiency may motivate excessive risk-taking in order to defend market shares (Koetter and Porath, 2007). *Second*, this study uses three types of banking risks that had significant effects in the occurrence of the financial crisis, and investigates whether the level of these risks at banks matters during the crisis period (2007-2009) in terms of bank efficiency. *Third*, this study investigates in what way the financial crisis affects bank cost and profit efficiencies in the four EU groups and whether one group is affected more by the crisis than the others. *Finally*, this study contributes to the European bank efficiency literature by relating banking efficiency and risks to banking stock performance in the EU using the largest number of the EU countries, to the best of our knowledge. The unique experience of the European Union and the related financial and banking integration between its member states is worthy of study for many years to come.

1.3 Research Methodology and Data

The stochastic frontier analysis (SFA), as a parametric approach, and the data envelopment analysis (DEA), as a non-parametric approach, are the most widely used efficiency frontier methods in the literature (Berger and Humphrey, 1997). Data envelopment analysis is a linear mathematical programming technique and its advantage is that it is simple to apply because no functional forms and preliminary restrictive assumptions are needed, and it performs well with a small sample of firms.

However, the main disadvantage of the DEA is that it does not account for random errors, and therefore it might overestimate the inefficiency term [Berger and Humphrey (1997) and Coelli *et al*. (2005)]. On the other hand, the SFA is a stochastic approach that uses econometric tools to estimate efficiency frontier. The main advantage of the SFA is that, contrary to the DEA, it allows for random error by using a composed error model where inefficiency follows an asymmetric distribution and random error follows a symmetric distribution. Therefore, the SFA provides the technique by which the inefficiency term can be disentangled from the error term, resulting in an unbiased estimation of inefficiency differences that are under the control of banks' management and independent of exogenous factors [Berger and Humphrey (1997) and Hollo and Nagy (2006)].

In this thesis the stochastic frontier approach (SFA) is adopted to measure bank efficiency for the advantage aforementioned. Also, the SFA can account for risk preference and environmental differences between countries and banks using one stage analysis which allows for more robust and unbiased efficiency estimates, while DEA does not allow for that (Weill, 2003). Moreover, as mentioned earlier, the DEA approach performs better with a small sample which is not the case in this study, hence the SFA is superior and more suitable to be used in this study. We use the Battese and Coelli (1995) one-step SFA estimation procedure to generate bank cost and profit efficiency estimates and investigate their determinants, as opposed to the two-step model. The two-stage approach has been criticised by Wang and Schmidt (2002) who argue that the assumption that the inefficiency component is independently and identically distributed across banks is violated in the second step of the approach, where the inefficiency estimate is assumed to be dependent on different explanatory variables.

With regard to investigating the determinants of bank stock return, this study uses multiple regression models for panel data in which bank stock returns are regressed against different explanatory variables; such as bank efficiency and risks. The fixed effects model (FEM) and the random effects model (REM) are the estimation techniques to be adopted, while the Hausman test is used to choose between the two estimation techniques. We run different diagnostic tests to investigate problems such as multicollinearity, heteroskedasticity and autocorrelation and to account for them where they exist.

The thesis uses unbalanced panel dataset, composed of 4250 observations corresponding to 947 commercial banks operating in the 27 EU states over the period 2004-2010. The number of commercial banks included in the study sample from the old EU states (745 banks) dominates the number of banks from the new EU states (202 banks). Regarding the GIIPS countries, 202 commercial banks operating in these countries are included in the sample. The data used to measure bank efficiency and its determinants are collected from balance sheets and income statements of commercial banks provided by "Bankscope" database of BVD-IBCA. It is important to mention here that all listed banks in the EU member states were required to adopt the International Financial Reporting Standards (IFRS) from 2005 rather than the US Generally Accepted Accounting Principles (GAAP). Data concerning bank stock prices are also collected from the "Bankscope" database on a monthly basis. Macroeconomic data, on the other hand, are collected from the "Datastream" database developed by Thomson Financial Limited and from the IMF's International Financial Statistics.

1.4 Structure of the Study

The structure of this thesis is as follows:

Chapter 2 aims to introduce the theoretical framework regarding productive efficiency and efficiency measurements, to provide a summary of the types of risk that can be faced by banks as well as to present summaries of the world financial crisis and the Eurozone crisis. It briefly discusses the differences between the conventional methods of measuring performance and the frontier methods of measuring firms' efficiency. Moreover, it provides a framework of productive efficiency where technical, allocative, cost and revenue efficiencies are introduced and defined. In addition, this chapter reviews the main frontier techniques; parametric and non-parametric, that can be used to measure efficiency. Different types of banking risk and the relationship between risk and return are also analysed in this chapter. Finally, this chapter explains briefly the world financial crisis (2007-2009) and its relationship with banking risks as well as it sheds light briefly on the Eurozone debt crisis.

Chapter 3 sheds light on the main changes in European banking structure and financial regulations that the European Union has gone through in order to create more unified and stabilised banking systems. It discusses the process of deregulation and re-regulation in the European banking markets and the related legislative changes since the late 1970s. Furthermore, this chapter covers briefly the introduction of the European Monetary Union (EMU) and the adoption of the Euro as well as the stages and conditions related to them. It also uses five structural banking indicators to explore and analyse the structure of the EU banking system and the changes associated with it over the period 2004-2010. Additionally, the Eastern enlargement processes of the EU together with the transition process through which the accession countries have gone through, are discussed in this chapter. Moreover, literature review on European banking efficiency and risk and the relationship between them is reviewed in this chapter. The main focus in this literature review is on European studies of banking efficiencies and risks using different measurements and different time periods.

Chapter 4 has the objective of describing and explaining the methodology used to measure bank efficiency and risk in the EU banking system. It briefly defines the stochastic frontier analysis (SFA) and the models associated with this frontier method for panel data. Also, this chapter introduces the SFA translog functional forms for cost and profit efficiencies and the specifications of such models based on the Battese and Coelli (1995) one-step procedure. Three financial ratios are defined as the measures to represent three types of banking risk; insolvency, credit and liquidity risks. Additionally, Chapter 4 provides dataset description and defines variables for bank efficiency and its determinants as well as banking risk. This includes efficiency inputs and outputs and the environmental variables that can be considered as efficiency correlates.

Chapter 5 provides banking efficiency analysis and empirical results which aim to investigate and compare cost and profit efficiency levels based on common and separate frontiers. It introduces cost and profit efficiency mean estimates for the four EU groups adopted in this study and for the EU countries individually and analyses efficiency by bank size. This chapter also discusses the evolution and dispersion of bank cost and profit efficiencies over the seven years under study and provides comparisons between the country groups, particularly the efficiency gap between the old and the new EU member states. In this chapter, we also examine the influence of the world financial crisis (2007-2009) on cost and profit efficiencies for the four country groups by comparing the levels of efficiency in the crisis, non-crisis and the entire time period under study.

Chapter 6 aims to introduce a descriptive analysis for the aforementioned three types of banks risk and to investigate the correlates of bank efficiency. It starts by analysing and discussing graphically the level of risks in the four EU groups and providing comparisons between them. Then this chapter examines and discusses the determinants of bank cost and profit inefficiencies. The main focus in these determinants is on the risk variables and their effects on efficiency overall and during the crisis time. In addition, other explanatory variables that might affect bank efficiency are also investigated; some of these variables are micro while others are macro variables in addition to industry-specific variables. At the end of this chapter, the rank order correlation of efficiency scores and traditional non-frontier performance measures are also investigated.

Chapter 7 aims to investigate the effects of different factors on commercial banks' stock returns, particularly efficiency and risk variables in the EU markets over the period from 2004 to 2010. First, it reviews the literature on the relationship between bank efficiency and stock performance and between risk and stock performance. Furthermore, this chapter explains the methodology used to investigate the effects of different factors including bank efficiency and various risk variables, on bank stock returns. This includes a summary of fixed and random effects models for panel data and the diagnostic tests related as well as the two regression model specifications adopted in this chapter. Also, this chapter defines the dataset and the dependent and independent variables used in the empirical analysis. The empirical results generated by the two regression models and the related analysis and discussion are also provided and reported in this chapter.

Chapter 8 is the concluding chapter that summarises the main empirical findings and the limitations of this study.

Chapter 2

Efficiency, Risk, and Global Financial Crisis: Theory and Measurement

2.1 Introduction

The main objective of this chapter is to introduce the theoretical framework regarding productive efficiency and efficiency measurements, to provide a summary of the types of risk that banks can be exposed to as well as to present summaries of the world financial crisis and the Eurozone crisis. Section 2.2 briefly discusses the differences between the conventional methods (financial ratios) of measuring performance and the methods of frontier that have gained popularity in banking efficiency measurement studies in the last two or three decades. Section 2.3 provides a framework of productive efficiency. In this section technical, allocative, cost and revenue efficiencies are introduced using a graphical explanation to the concept of the "best-practice" frontier. Technical efficiency can be decomposed into pure technical and scale efficiency while this section also sheds light on the definitions of economies to scale and scope.

Section 2.4 reviews the main frontier techniques that can be used to measure efficiency. These frontier techniques can be divided into non-parametric and parametric techniques. The non-parametric techniques are mathematical programming approaches and they include Data Envelopment Analysis (DEA) and Free Disposal Hull (FDH). On the other hand, the parametric techniques require pre-specified functional forms and they include the Stochastic Frontier Analysis (SFA), Distribution Free Approach (DFA), and Thick Frontier Approach (TFA). Section 2.5 introduces an overview of risks at banking institutions and defines the relationship between risk and return utilising Capital Asset Pricing Model (CAPM). Moreover, this section defines four important risks that banks face, namely; insolvency risk, credit risk, liquidity risk, and market risk, while capital requirements set by regulators to reduce such risks are also discussed. Section 2.6 explains briefly the world financial crisis (2007-2009) and its connection with bank risks, while section 2.7 gives a brief summary of the

Eurozone debt crisis and its causes in the GIIPS countries. Finally, section 2.8 summarises this chapter.

2.2 Conventional Versus Frontier Efficiency Methods

Bank performance studies usually adopt two kinds of methods; the frontier methods and the conventional non-frontier methods (i.e. financial ratios). The conventional methods are based on simple cost and profit analysis that can be implemented using simple financial ratios, such as return on assets ratio (ROA), return on equity (ROE), capital assets ratio, cost to income ratio as well as CAMELS[2] approach, etc. However, recent banking efficiency studies tend to use frontier methods more than financial ratios as an implicit consensus on the superiority of the frontier methods. Even though financial ratios are easy to apply and useful to give a swift and preliminary image of the performance of banks when they are compared with previous periods and with other banks' performances, they still have shortcomings. For example, Yeh (1996) argues that a major disadvantage of financial ratios is that "each single ratio must be compared with some benchmark ratios one at a time while one assumes that other factors are fixed and the benchmarks chosen are suitable for comparison" (p.980). The author adds that this problem can be fixed by combining a group of financial ratios to give a better picture of the firm's performance; however, the aggregation of those ratios can be a difficult and complex task. In addition, financial ratios are short-term measures that cannot reflect the effect of the current management's actions and decisions on the long-term performance of the firm [Sherman and Gold (1985) and Oral and Yolalan (1990)]. These criticisms in addition to other performance measurement considerations highlight the need for more robust performance measuring techniques, such as the efficiency frontier methods.

The frontier methods (non-parametric and parametric) are based on the idea of constructing a best-practice frontier against which relative performances of firms

[2] CAMELS is an international bank rating system to measure the soundness and performance of banks and finance companies. It includes six factors: C - Capital adequacy, A - Asset quality, M - Management quality, E – Earnings, L – Liquidity, S - Sensitivity to Market Risk. For more on CAMELS, see Grier (2007).

(banks) are measured. These methods were developed to generate more reliable and superior performance measuring results compared to the non-frontier methods. Berger and Humphrey (1997:176) state that “frontier analysis provides an overall, objectively determined, numerical efficiency value and ranking of firms […] that is not otherwise available.” The authors add that by evaluating the performance of firms using the frontier methods, very useful information can be generated regarding which institutions perform well and which perform poorly. This information can be used effectively 1) to help government policy makers and regulators evaluate the potential consequences of deregulation, consolidations, or market structure on firms’ performances; 2) to support the process of conducting research on industry or its firms’ efficiency, or making comparisons between efficiency of different techniques used; or 3) to help poorly-performing firms improve their performances and decrease the gap with the well-performing firms by specifying “best practices” and “worst practices” of the sample firms[3]. These advantages of the frontier techniques make them superior and more appropriate to be adopted in this thesis than the non-frontier methods.

In spite of the aforementioned advantages of the frontier methods, frontier methods are not without limitations as Weill (2003b) argues. The first statistical problem of the efficiency frontiers is that contrary to the financial ratios, the frontier methods measure the relative efficiency of firms and hence, some of these methods, such as the SFA, need a large sample to perform well. As different frontier approaches (parametric and non-parametric) can be adopted, they might generate different efficiency results for a similar sample of firms (Bauer *et al.*, 1998). The final problem is the definition of inputs and outputs that are required for the estimation of cost/profit efficiencies when using the frontier methods, where more than one approach can be used to define inputs and outputs (to be discussed later in the methodology chapter). As in this study, a large sample of banks operating in the entire EU region is used, in addition to adopting only one frontier approach (the SFA), the first two problems mentioned above are solved, leaving the last problem to be discussed later when defining the inputs and outputs for the cost/profit frontiers in the methodology chapter.

[3] For more detailed discussion, refer to Berger and Humphrey (1997).

2.3 The Framework of Efficiency

The aim of this section is to shed light on a number of efficiency concepts that can be calculated relative to a given frontier. The focus is on the pioneering work of Farrell (1957) which paved the way to present the concept of overall (productive) efficiency using a production frontier. The overall efficiency can be decomposed into technical and allocative efficiency, while technical efficiency in turn can be decomposed into pure technical and scale efficiencies. All these efficiency measures as well as the concepts of cost efficiency, revenue efficiency, economies of scale and scope are discussed in this section.

2.3.1 Technical, Allocative, Cost and Revenue Efficiency

Before embarking on presenting and defining frontier efficiencies, it is important to refer to the early studies of Debreu (1951), Koopmans (1951), Shephard (1953, 1970), and Farrell (1957). These studies were superior in defining the firm's efficiency as the radial distance of its real performance to a frontier. If a production function is considered, this frontier represents the maximum level of outputs that can be achieved given a certain level of inputs, or alternatively it represents the minimum level of inputs that can be used to generate a certain level of outputs. In spite of the importance of all these studies in paving the way to develop different frontier methods to measure the efficiency of a firm, Farrell's (1957) study is superior in presenting a clear explanation to the production function. Farrell (1957) decomposes the overall (or economic) efficiency into allocative (or price) efficiency and technical efficiency. The allocative efficiency reflects the ability of a firm to use the optimal proportion of inputs given their respective prices and production technology. On the other hand, technical efficiency reflects the ability of a firm to obtain the maximum level of outputs given a set of inputs, or the ability of a firm to minimise input utilisation given a set of outputs.

To illustrate the analysis carried out by Farrell (1957), we discuss efficiency from *an input-oriented* perspective where the focus is on reducing inputs utilisation. Consider a firm that produces only one output Y from two inputs X1 and X2, under the assumption of constant returns to scale (CRS). The unit isoquant SS' in Figure 2.1 represents the various combinations of inputs X1 and X2 by which the firm can produce unit output Y when it is perfectly efficient. Put another way, SS' shows the minimum combinations of inputs needed to produce certain output level. Therefore, it can be argued that any firm which uses a combination of inputs that is located on the unit isoquant SS' to produce a unit of output is considered technically efficient. On the other hand, a firm that uses a combination of inputs that is located above or to the right of the isoquant, such as the one defined by point C is considered as technically inefficient since it uses an input combination that is more than enough to produce a unit of outputs. The technical inefficiency of that firm can be presented by the distance QC along the ray 0C, which is the amount by which all inputs could be proportionally reduced without reducing the amount of output. This technical inefficiency can be expressed as a percentage by the ratio QC/0C, which refers to the percentage by which all inputs need to be reduced in order to achieve technically efficient production. The *technical efficiency* (TE) of a firm can hence be measured by the ratio 0Q/0C, which takes a value between zero and one. A value of one implies that a firm is fully technically efficient.

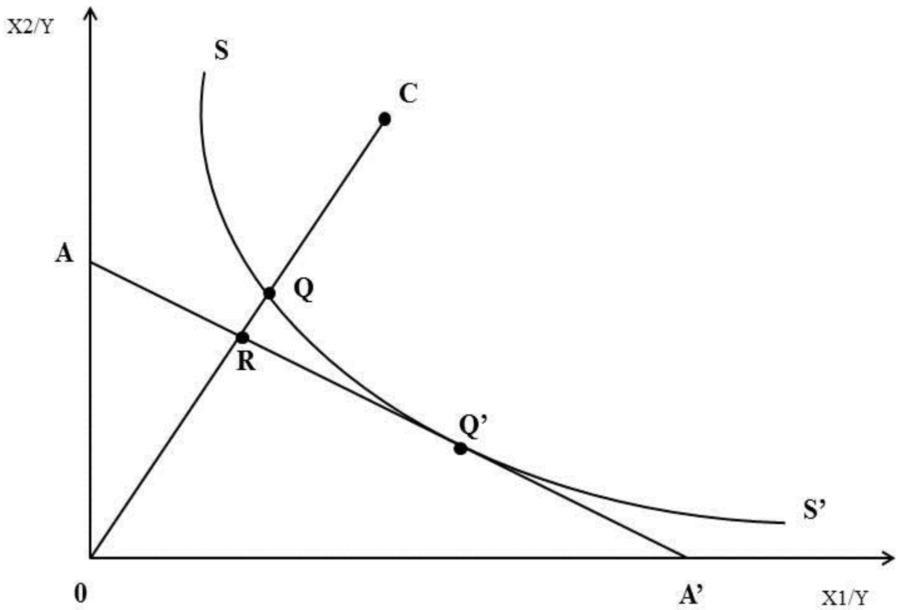

Figure 2.1. Farrell's Efficiency Measures (input-oriented) [adapted from Coelli *et al.* (2005: 52)]

In the presence of input price information, the *allocative efficiency* can be derived from the isocost line AA’ shown in Figure 2.1. AA’ represents the cost minimising line and its slope represents the input price ratio. The allocative efficiency can be measured by the ratio 0R/0Q, and the distance RQ represents the reduction in production costs which a firm needs to achieve in order to move from a technically but not allocatively efficient input combination Q to both a technically and allocatively combination Q’. A firm operating at point Q’ is both technically and allocatively efficient. Let W represent input prices vector and X represent the input vector associated with point C. Also, let X` and X* represent the input vector associated with the technically efficient point Q and the cost-minimising point Q’, respectively. We can now calculate technical efficiency (TE) and allocative efficiency (AE) measures as follows:

$$AE = \frac{W'X^*}{W'X`} = \frac{0R}{0Q} \quad ; \quad TE = \frac{W'X`}{W'X} = \frac{0Q}{0C} \qquad (1)$$

And in the presence of input price information, another efficiency measure can be calculated. This measure is *cost efficiency* which can be defined as the ratio of input costs associated with input vector X and X*, associated with points C and Q’, respectively. Therefore, cost efficiency (CE) can be calculated by the following ratio:

$$CE = \frac{W'X^*}{W'X} = \frac{0R}{0C}$$

Given the measures of technical efficiency and allocative efficiency, the total *overall cost efficiency* can be expressed as a product of both measures as follows:

$$CE = TE \times AE = \frac{0Q}{0C} \times \frac{0R}{0Q} = \frac{0R}{0C} \qquad (2)$$

All the three efficiency measures take values between zero and one.

While the above input-oriented efficiency measure sheds light on reducing input quantities proportionally to produce certain amount of outputs, the *output-oriented* efficiency measure refers to the idea of increasing output quantities proportionally using specific amount of inputs. Meaning that in the case of output-oriented, the focus is on increasing outputs produced. To illustrate this, consider a firm that produces two outputs Y1 and Y2 using a single input X1 under the assumption of constant returns to scale (CRS). In Figure 2.2 ZZ' is a unit production possibility curve that represents the maximum combinations of outputs Y1 and Y2 that can be produced using a certain input amount. Therefore, a firm operating on the ZZ' curve is considered to be technically efficient, while a firm operating at a point below ZZ' (point K) is an inefficient firm because it uses the same input amount to produce less than possible output combination. The distance KB represents the amount by which outputs can be increased without increasing inputs, and, hence, this distance represents technical inefficiency that can be calculated by the ratio 0K/0B.

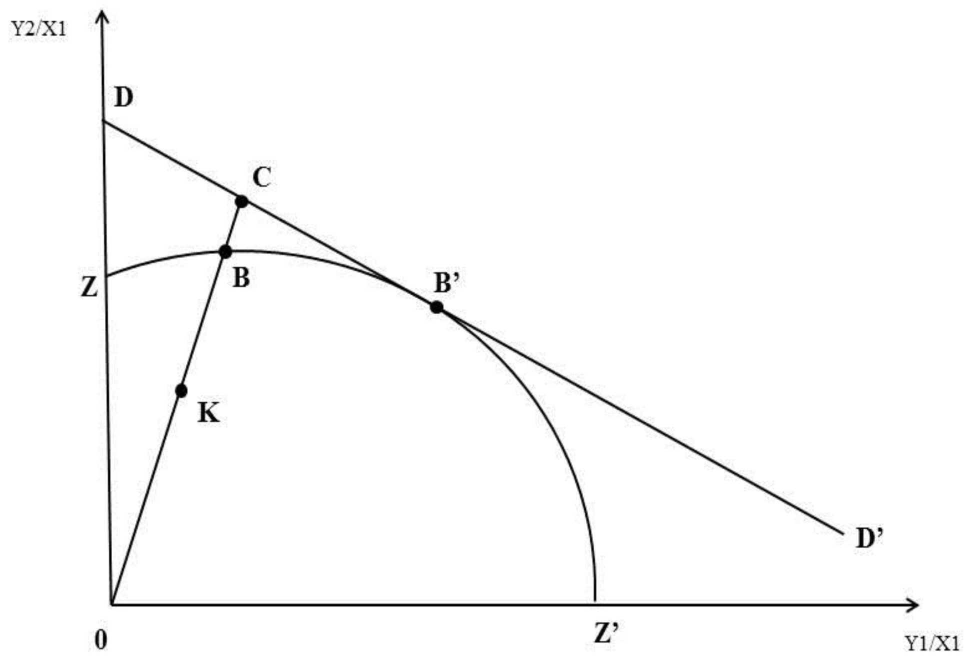

Figure 2.2. Farrell's Efficiency Measures (output-oriented) [adapted from Coelli *et al*. (2005: 55)]

As in the case of input-oriented efficiency treatment, in the presence of output prices isorevenue DD' can be established as can be seen in Figure 2.2, and it is the revenue maximising line. The allocative efficiency can be measured by the ratio 0B/0C, and the distance BC represents the increase in production revenue a firm needs to achieve to move from point B (technically efficient) to point B' (both technically and allocatively efficient). If P represents observed output price and q, q`, and q* represent output vector of firm associated with point K, point B, and point B', respectively, then Farrell's efficiency measures are as follows:

$$AE = \frac{p'q^{`}}{p'q*} = \frac{0B}{0C} \quad ; \quad TE = \frac{p\prime q}{p'q^{`}} = \frac{0K}{0B} \qquad (3)$$

And the output prices, also, can be utilised to calculate the *revenue efficiency:*

$$RE = \frac{p'q}{p^{'}q*} = \frac{0K}{0C}$$

Given the measures of technical efficiency and allocative efficiency, the total *overall revenue efficiency* can be expressed as a product of both measures as follows:

$$RE = TE \times AE = \frac{0K}{0B} \times \frac{0B}{0C} = \frac{0K}{0C} \qquad (4)$$

And as in the case of input-oriented measures, all the three efficiency measures are bounded between zero and one.

If information on both input prices and output prices is available, then *profit efficiency* can be calculated by combining the two analyses above into one analysis, taking into consideration both cost and revenue efficiencies. In this sense, a profit efficient firm maintains a production process at which the lowest costs are used to produce the maximum revenues given input and output prices. In the methodology chapter, we will present a comprehensive discussion on how to measure both cost and profit efficiencies using the method of Stochastic Frontier Analysis (SFA).

2.3.2 Pure Technical and Scale Efficiency

Although a firm can be both technically and allocatively efficient, it might still operate at a scale of operation that is not optimal. In the previous section we presented efficiency measures based on *constant returns to scale* assumption, but this assumption does not always hold. A firm might be operating within the *increasing returns to scale* or within *the decreasing returns to scale* part of the production function. In other words, the firm might be operating under the assumption of variable returns to scale (VRS). Therefore, the technical efficiency, in general, can be decomposed into *pure technical efficiency (PTE)* and *scale efficiency (SE)* (Coelli *et al*., 2005). To illustrate how to calculate these two efficiency measures, we assume a one-input, one-output production function considering the input orientation perspective[4] in Figure 2.3.

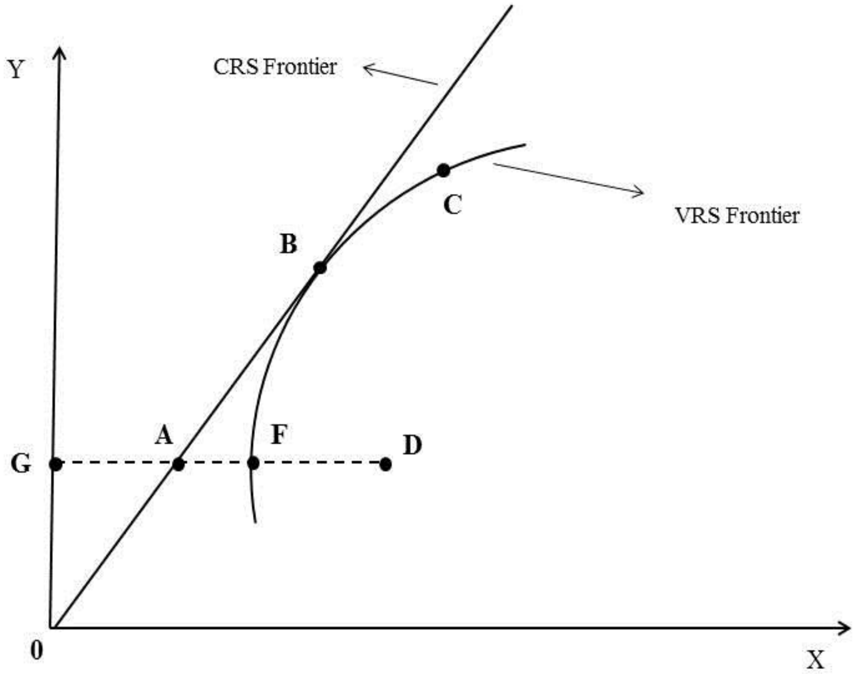

Figure 2.3. Pure Technical and Scale Efficiency [adapted from Coelli *et al*. (2005: 59)]

Firms operating at points F, B, and C are all technically efficient as they are operating on the production frontier. However, firm F is operating within the increasing returns to scale portion of the production frontier and can be more productive by increasing its operating scale towards point B. Firm C, on the other hand, is operating within the decreasing returns to scale of the production frontier and can be more productive by decreasing its operating scale towards point B. A firm operating at point B, that is located on the constant returns to scale frontier, is operating at the most productive scale size or at the technically optimal productive scale (TOPS) and cannot be more productive. Coelli *et al*. (2005: 59) state that, "A scale efficiency measure can be used to indicate the amount by which productivity can be increased by moving to the point of TOPS." The firm represented by point D in Figure 2.3 is technically inefficient

[4] A similar analogy can be followed to illustrate pure technical and scale efficiency measures under output orientation perspective.

because it is operating below the production frontier. The pure technical efficiency (PTE) of this firm under the VRS technology is equal to the ratio GF/GD, while the scale efficiency (SE) is represented by the distance from point F to the CRS technology and is equal to GA/GF. The value of SE is unity when operating at the constant return to scale, as in the case of point B, while it is less than unity for firms F and C because they are operating on the VRS frontier but not on the CRS frontier. Thus, scale efficiency can be calculated by dividing total technical efficiency by pure technical efficiency. Or alternatively, scale efficiency (SE) is equal to the ratio of technical efficiency under the CRS assumption to the technical efficiency under the VRS assumption; $SE = \frac{TE_{CRS}}{TE_{VRS}}$ = (GA/GD)/ (GF/GD) = GA/GF (5).

2.3.3 Economies of Scale and Scope

Although this study does not focus on the economies of scale and the economies of scope, we briefly introduce the two concepts so as to distinguish the cost advantages related to these concepts from cost efficiency. *Economies of scale* (or returns to scale) can be defined as "aspects of increasing scale that lead to falling long-run unit costs" (Wilkinson, 2005: 227). Specifically, economies of scale (or increasing returns to scale) exist at a firm if a proportionate increase in the firm's outputs would lead to a less than proportionate increase in its total average costs. On the other hand, diseconomies of scale (or decreasing returns to scale) exist if a proportionate increase in the firm's outputs would lead to a more than proportionate increase in its total average costs. Finally, constant returns to scale exist when a proportionate increase in a firm's outputs would lead to the same proportionate increase in its total average costs (Baye, 2002).

Figure 2.4 illustrates the idea of economies and diseconomies of scale by exploiting the relationship between the long-run average costs and outputs. LRAC is the long-run average costs curve that takes a U-shape. As can be seen from the figure, increasing the output production from point 0 towards point Q* is associated with a decline in the LRAC, indicating economies of scale. In other words, increasing a firm's size of operation between 0 and Q* decreases its average costs. On the other hand, increasing the output production beyond point Q* is associated with a rise in the LRAC curve, indicating diseconomies of scale. That is to say, increasing a firm's size of operation after point Q* increases its average costs.

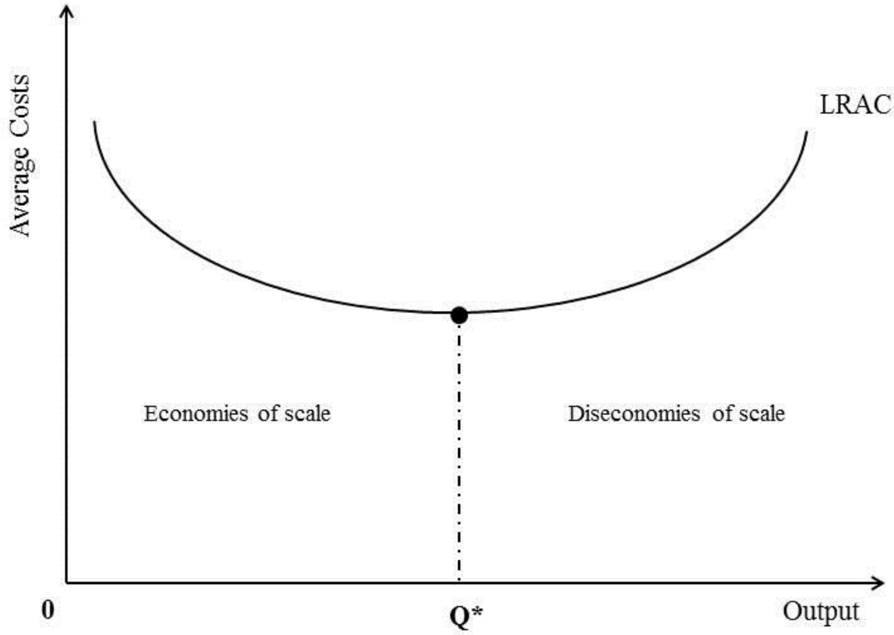

Figure 2.4. Economies and Diseconomies of Scale [*source:* Baye (2002: 184)]

Economies of scope exist when the total costs of producing two or more products jointly is less than the total costs of producing those products separately or independently (Molyneux *et al.*, 1996). Conversely, diseconomies of scope occur when the joint production of two or more products is more costly than separate or independent production of those products. To illustrate this, consider a firm that produces two outputs Q1 and Q2. If the two outputs are produced independently, their separate cost functions are C (Q1, 0) and C (0, Q2), while, if they are produced jointly, then their joint production cost is C (Q1, Q2). If the total costs of producing the two outputs jointly is less than the combined cost of producing the two outputs separately, then economies of scope exist and that can be expressed as $C(Q1, Q2) < C(Q1, 0) + C(0, Q2)$. If the inequality sign is reversed, then diseconomies of scope exist. For banks, economies of scope can be exploited if producing multiple financial and banking services jointly is less costly than producing those services separately, which would lead to cost savings, and the reverse is true (diseconomies of scope exist) when the joint production of services is more costly than the separate production of those services. Given the example above, the overall economies of scope can be measured as follows:

$$SCOPE = \frac{C(Q1,0)+C(0,Q2)-C(Q1,Q2)}{C(Q1,Q2)} \qquad (6)$$

Where SCOPE > 0 indicates overall economies of scope and SCOPE < 0 indicates diseconomies of scope.

2.4 The Measurement of Efficiency

In this section we present a brief overview of the frontier efficiency methods which differ mainly in the assumptions of data regarding the functional form of the best-practice frontier, whether or not random error is taken into consideration, and the technique used to disentangle inefficiency term from random error if random error is considered (Berger and Humphrey, 1997). We start by introducing the non-parametric efficiency methods, then we present the parametric methods.

2.4.1 Data Envelopment Analysis (DEA)

Data envelopment analysis is a linear mathematical programming technique that can be used to construct the efficiency frontier (best-practice frontier) against which the relative performance of different homogenous entities called *Decision Making Units* (DMUs) can be measured[5]. This method was suggested by Boles (1966), Shephard (1970) and Afriat (1972); however, it was first applied by Charnes, Cooper and Rhodes (CCR) (1978). Charnes, Cooper and Rhodes (1978) proposed the data envelopment analysis as a mathematical programming technique based on input-oriented model assuming constant returns to scale (CRS). This technique allows for multiple inputs and outputs for a sample of decision making units (DMUs). Following studies of data envelopment analysis, such as Färe, Grosskopf and Logan (1983), Banker, Charnes and Cooper (BCC) (1984), extending the DEA method was suggested by Charnes, Cooper and Rhodes (CCR) (1978) so as to be applied assuming variable returns to scale (VRS). This method is called data envelopment analysis because the

[5] For more comprehensive explanation, see [Färe *et al*. (1985), Ali & Seiford (1993), and Lovell (1994)].

data for the best practice DMUs envelop the data for the rest of the DMUs in the sample. The DEA frontier is formed as a linear combination of the best practice observations that lead to the formation of a convex production possibility set. The DEA is a technique that assumes that there are no random errors, so that all deviations from the efficiency frontier are considered as inefficiency, and this is the main difference between this approach and the parametric approaches, such as the stochastic frontier analysis (SFA), as will be discussed later on in this section.

2.4.2 Free Disposal Hull (FDH)

The other non-parametric approach is the Free Disposal Hull (FDH) approach, which is a special case of the data envelopment analysis (DEA). The FDH requires minimal production technology assumptions compared to the other frontier approaches, including the DEA. For instance, the FDH relaxes the assumption of convexity of the production possibility set. The FDH approach was suggested as a new frontier method for measuring productive efficiency by Deprins *et al.* (1984) and Tulkens (1986, 1993). De Borger *et al*. (1994) argue that the FDH approach has some advantages; for example, it does not make strong assumptions concerning the production technology and it is a non-parametric approach that does not depend on a particular parametric form to be chosen in order to do the economic analysis. However, the authors state that its major shortcoming is that it is “sensitive both to the number and the distribution of the observations in the data set, and to the number of input and output dimensions considered” (p.656). Moreover, Tulkens (1993) argues that the FDH is compatible or interior to the DEA frontier and therefore it overestimates the average efficiency compared to the DEA approach. Between the two non-parametric frontier methods aforementioned, the DEA is much more popular and widely used in banking efficiency studies compared to the FDH approach.

2.4.3 Stochastic Frontier Analysis (SFA)

As opposed to the non-parametric frontier approaches, the parametric frontier approaches are more sophisticated and require functional forms and assumptions to construct a stochastic optimal frontier to measure efficiency. In addition, parametric approaches are capable of combining both technical and allocative efficiencies. The best-known parametric technique and the most widely used for measuring efficiency among others is the Stochastic Frontier Analysis (SFA) (it is also known as the

Economic Frontier Approach, EFA). The SFA was independently developed by Aigner *et al*. (1977) and Meeusen and van den Broeck (1977) and was motivated by the idea that not all deviations from the efficiency frontier might be under the control of the management of the DMUs under study. The SFA specifies a functional form for cost (or profit) frontier where a composed error term is considered so as to separate inefficiency term from random noise using some distributional assumptions. The random noise is assumed to follow a symmetric (two-sided) distribution while the other non-negative part of the composed error term that represents inefficiency follows a particular one-sided distribution.

To illustrate the idea upon which the SFA is built, we refer to a simple example of cost efficiency function. Consider a single-equation stochastic cost function form:

$$lnC_i = ln\, C(Y_i, W_i) + \varepsilon_i = ln\, C(Y_i, W_i) + \nu_i + u_i \qquad (7)$$

Where C_i is the total costs, Y_i is a vector of outputs, W_i is an input price vector, ν_i is a two-sided noise component, and u_i is a non-negative disturbance term that represents inefficiency (the deviation from cost efficiency frontier). While the noise term ν_i is usually assumed to follow a normal distribution, different distributional assumptions with regard to the inefficiency term u_i have been proposed. Those distributions range from half-normal and exponential distributions proposed by Aigner *et al*. (1977) and Mester (1993) to truncated normal and gamma distributions [Berger and Humphrey (1997) and Kumbhakar and Lovell (2000)]. To obtain the parameters of the frontier function and the composed error, maximum likelihood (ML) estimation or the corrected ordinary least squares can be used. However, Kumbhakar and Lovell (2000) argue that the ML estimation generates more efficient estimates by utilising the distributional assumptions when the independence of factors and regressors matters. We will discuss the stochastic frontier analysis (SFA) for panel data models in detail in the methodology chapter.

2.4.4 Distribution Free Approach (DFA)

The distribution free approach (DFA) was developed by Berger (1993) following earlier panel data approaches introduced by Schmidt and Sickles (1984). Similar to the SFA, DFA specifies functional forms for the efficiency frontier, however, it differs from the SFA in the way it disentangles inefficiency term from the random error. It assumes that inefficiency is persistent over time and the random error tends to zero-value over time as the random errors cancel each other by averaging. In the panel data model, cost or profit functions are estimated for every period of the panel data where the composed residual is comprised of inefficiency and random error terms. As the random errors cancel each other over time, the average of residual from all the regressions is an estimate of inefficiency.

The DFA has the advantage of easy implementation as it does not require strong assumptions as to the distribution of inefficiency term or random error. For this reason, and contrary to the SFA, the cost or profit function based on the DFA can be estimated using generalised least squares (GLS), as done by Schmidt and Sickles (1984), or the ordinary least squares (OLS), as done by Berger (1993). However, the main drawback of the DFA is that it assumes that efficiency is persistent over time and the random error tends to zero-value average over time. Therefore, if the study period is too long then inefficiency might not be persistent over time, or if the study period is so short then error terms might not cancel each other, which might all generate misleading results.

2.4.5 Thick Frontier Approach (TFA)

The thick frontier approach (TFA) was developed by Berger and Humphrey (1991), and it differs from the other frontier parametric approaches in terms of the estimation of efficiency frontier. This approach estimates cost/profit function for the lowest/highest average cost/profit quartile of firms (considered as thick frontier), where firms' efficiencies are higher than the sample average efficiency, rather than estimating a precise efficiency bound. Moreover, a cost/profit function for the highest/lowest average cost/profit quartile is estimated too, where firms' efficiencies are lower than the sample average efficiency. The main assumption here is that the difference between the two cost/profit functions (related to the highest and the lowest quartiles) is attributed to inefficiencies and exogenous factors, while the error terms within the highest and lowest quartiles represent measurement error and luck. This approach is not widely used in banking efficiency studies because the aforementioned assumption is difficult to be held exactly, resulting in imprecise estimates of banking inefficiencies, in addition to the problems of skewing and heteroskedasticity of error terms that might result from dividing data into quartiles (Matousek and Taci, 2004).

Furthermore, a main disadvantage of this approach is that it does not provide estimated efficiency scores for individual firms, rather it provides an estimate of average efficiency for the whole tested sample. However, Berger and Humphrey (1991) argue that their main purpose of using the TFA is to obtain a basic idea as to the likely magnitude of efficiency and not to get an exact efficiency measurement.

2.4.6 What is the Best Frontier Method?

There is no consensus as to what frontier method is preferred for measuring banking efficiency, but the stochastic frontier analysis (SFA) and data envelopment analysis (DEA) are the most widely used efficiency frontier methods among the others discussed above (Berger and Humphrey, 1997). As the data envelopment analysis (DEA) is a non-parametric approach and the stochastic frontier analysis (SFA) is a parametric approach, then there must be differences in the application and the assumptions of both approaches. It is important to highlight such differences as only one approach (the stochastic frontier approach) will be adopted in this thesis. The advantage of the DEA method is that it is simple to apply because no functional forms and preliminary restrictive assumptions are needed, and it performs well with small sample of firms. In addition, as Oral and Yolalan (1990) argue, DEA performs well and provides meaningful efficiency results when firms use similar resources to provide similar services. The major disadvantage of the DEA is that it does not account for random errors[6] and therefore it considers all deviations from the efficiency frontier as inefficiencies resulting in the inclusion of exogenous variables in the inefficiency term, hence the inefficiency term might be overestimated [Berger and Humphrey (1997); Coelli *et al*. (2005); Weill (2003) and Murillo-Zamorano (2004)]. Another shortcoming of the DEA is that it is very sensitive to outliers because it envelops the outlier observations even though those outliers might be the result of an error and not real ones (Sarafidis, 2002, Havrylchyk, 2006).

On the other hand, the SFA is a stochastic approach that uses econometric tools to estimate efficiency frontier. The main weakness is that it "impose[s] more structure on the shape of the frontier by specifying a functional form for the cost [or profit] function" (Weill, 2003: 579). However, the main advantage of the SFA is that, contrary to the DEA, it allows for random error by using a composed error model

[6] For more on this shortcoming, see [Berger and Humphrey (1997) and Coelli *et al*. (2005)].

where inefficiency follows an asymmetric distribution (e.g. half normal, gamma, truncated normal) and random error follows a symmetric distribution (usually the standard normal). Therefore, the SFA provides the technique by which the inefficiency term can be disentangled from the error term, resulting in an unbiased estimation of inefficiency differences that are under the control of the firm's management and independent of exogenous factors [Berger and Humphrey (1997) and Hollo and Nagy (2006)]. In this thesis the stochastic frontier analysis (SFA) is the approach chosen to measure bank efficiency for the advantage mentioned above, where the random error is taken into account and inefficiency term can be disentangled from error term using some distribution assumptions. The sample used in this thesis is large, combining banking sectors in the European Union 27 member states, where there might be heterogeneity and different exogenous factors affecting banking efficiency scores and need not be included in the inefficiency term. Also, the SFA can account for risk preference and environmental differences between countries and banks which allow for more robust and unbiased efficiency estimates, while DEA does not allow for that (Weill, 2003). Moreover, as mentioned earlier, DEA approach performs better with a small sample which is not the case in this study, hence the SFA is superior and more suitable to be used in this study.

2.5 Risk in Banking Institutions

As this study will investigate different types of risk and the link between such risks and bank efficiency and stock performance, we briefly shed light on risks in banking institutions in this section. Commercial banks engage in different related activities that range from providing products and services to customers to intermediation and risk management. Risk management has to be an important issue to be considered when studying the activities of commercial banks. Merton (1989: 243) states that "an important part of the management of financial intermediaries is the management and control of the risk exposures created by issuing their financial products." Saunders and Cornett (2006) add that modern financial institutions are in the risk management business as they bear and manage risk on their customers' behalf by pooling risks and selling their services as risk specialists. This section aims at introducing an overview of banking risks and analysing the relationship between risk and return. The Capital

Asset Pricing Model (CAPM) is utilised to explain the trade-off between risk and return on an investment. Four banking risks are explained in this section; namely, insolvency risk, credit risk, liquidity risk, and market risk. Although banks face other types of risks, these risks are chosen because they will be adopted in this thesis to examine their level and their effects on bank efficiency and stock returns. Finally, the important role of bank capital in reducing risks and enhancing banking sector stability is highlighted through a brief discussion of the capital requirements based on Basle Accords.

2.5.1 Banking Risks Overview and CAPM

Risk in finance can be defined as the probability of making profits or losing money on an investment, or as Howells and Bain (2008) argue that risk is the probability that the actual return might not be the same as the expected return. Also, risk can be looked at as the uncertainty surrounding the outcome that would take place in the future, where more than one possible outcome might occur. The investigation of bank risk has led to different risk classifications proposed by authors based on their analytical purposes. For instance, Vyas and Singh (2011) argue that risk faced by banks belong mainly to two general groups. The first group is transactional risks, under which category market risk and credit risk are listed. The second group is operational risks that Vyas and Singh (2011: 17) define as “a risk arising from execution of a company’s business functions [such as] fraud risks, legal risks, physical or environmental risks, etc.” Greuning and Bratanovic (2009) classify bank risk into three categories; financial, operational, and environmental risks. Rose (1999) divides bank risks into six types; credit risk, liquidity risk, market risk, interest rate risk, earning risk, and solvency risk, while Jorion (1997) refers to three types of bank risks; business risk, strategic risks, and financial risks.

In general, there is a trade-off between risk and return on an investment. In other words, one would not invest in a risky investment unless they receive a return to compensate them for the risk implied by that investment, because people, in general, are risk-averse. To illustrate the relationship between risk and return, Sharpe (1964) and Lintner (1965) developed a capital asset pricing model (CAPM) that attempts to explain the relationship between risk and return on a financial security that helps determine the fair price of such security. The CAPM is based on the idea that if a security helps to stabilise a portfolio by making it in line with the market, then this security should earn a similar return as the market portfolio. While if the security increases the risk of a portfolio compared to the market portfolio, then the demand on this security will decrease by risk-averse investors leading its price to fall and its expected return will be higher than the market return. On the other hand, if the security makes a portfolio less risky compared to the market portfolio, then it will be in higher demand, leading its price to rise and its expected return to fall below the market return. Based on some assumptions, such as the existence of perfect or efficient market, investors are risk-averse, and no transaction costs exist, CAPM is defined by the following equation where only systematic risk is priced and measured by beta (β):

$$E(R_i) = R_f + \beta_i[E(R_m) - R_f] \qquad (8)$$

Where $E(R_i)$ is the expected return for a security (or asset) i, R_f is the risk-free rate of return available for investors, β_i is the measure of systematic risk (beta) for security i, and $E(R_m)$ is the expected return on market portfolio[7].

2.5.2 Insolvency Risk

Insolvency risk for a bank can be defined as “the potential disability of a bank to raise enough cash timely in order to meet payment obligations [and hence becomes insolvent]” (Matz and Neu, 2007: 178). This risk is closely related to financial gearing (leverage) as banks are highly leveraged (maintain high ratio of debt/equity) compared to other institutions. A bank must have enough capital (equity) in order to be able to absorb potential losses that might result from taking on excessive risks and hence remain solvent (has a positive net worth of shareholders’ equity), otherwise it might be forced into liquidation. Therefore, as bank capital is the difference between its assets and liabilities value, insolvency or capital risk refers to the decrease in the market value of its assets below the market value of its liabilities (Casu *et al.*, 2006). In this sense, bank capital is the cushion against the risk of failure by absorbing financial and operating losses until management becomes able to solve the bank’s problems and restore its profitability (Rose, 1999). For this reason, a bank with higher risk taken should maintain greater amount of capital, and this is the principle behind the Basle capital requirements (as will be explained later in this chapter).

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[7] [7] For more on CAPM, see [Arnold (2008) and Pilbeam (2005)].

Banks usually prefer to hold less capital and larger debts to finance their investments because of the higher costs associated with raising equity capital. In general, as Arnold (2008) argues, raising capital by issuing new shares is more costly than obtaining loans (debts) because of the direct costs associated with issuing shares and more importantly, because the rate of return required by shareholders is higher than the rate of return (interest rate) on issuing bonds (debts). Also, shareholders' dividends are paid out of after-tax profits, while interest payments on loans are tax deductible. Moreover, higher capital means lower returns on equity holders because, as discussed by Mishkin and Eakins (2012), the return on equity (ROE) is negatively related to equity capital according to the following equation:

$$Return\ on\ Equity\ (ROE) = Return\ on\ Assets\ (ROA) \times \frac{Assets}{Equity\ Capital}\ (or\ Equity\ Multiplier) \quad (9)$$

Therefore, banks prefer to maintain less capital so as to reduce their costs and increase their profits, or in other words, banks tend to maintain less capital in order to increase their cost and profit efficiencies.

2.5.3 Credit Risk

Credit risk can be defined according to the Basle Committee on Banking Supervision (2000: 1) as "the potential that a bank borrower or counterparty will fail to meet its obligations in accordance with agreed terms." Tapiero (2004) argues that with regard to credit risk, uncertainty stems from two sources: default by a party to a financial contract or changes in the present value of future cash flows that might result from fluctuations in the financial market conditions or changes in the economic environment or interest rates. Banks' management should give close attention to the creditworthiness of their borrowers so as to decrease the probability of default on their loans, and hence decrease the probability of bank failure as banks usually tend to hold little equity capital. Bank managers must decrease the amount of credit losses by building a diversified portfolio and should investigate the ability of their borrowers to pay their loans before and after they issue the loans.

As loans usually constitute the largest part of banks' assets, it is highly important for banks to decrease the credit risk associated with issuing loans by setting up sound standards to investigate the creditworthiness of banks' borrowers. One measure of bank credit risk is the ratio of non-performing loans to total gross loans, the higher this ratio is, the higher the level of credit risk that a bank has. With higher level of credit risk, costs related to monitoring, screening, working out loans, or selling bad loans increase, this in turn decreases the cost efficiency of the bank. Furthermore, the higher the level of credit risk associated with higher non-performing loans (for example), the higher the costs associated with monitoring and working out, selling, or writing-off the bad loans and the higher the expenses related to the loan-loss provisions. This in turn would decrease banks' profits and therefore would lead to lower bank profit efficiency.

2.5.4 Liquidity Risk

Liquidity (or funding) risk can be defined as the potential that a bank (or a firm) will be unable to meet its obligations as they fall due because they lack the ability to liquidate some of their assets or raise enough funding from new source at reasonable costs. Banks must have sufficient cash and borrowing capacity in order to meet deposits withdrawal, net loan demand, and other cash needs (Rose, 1999). As it might be confusing, Hull (2010) distinguishes solvency from liquidity. He argues that solvency refers to the idea that a bank has more assets than liabilities and hence its equity capital is positive. On the other hand, liquidity refers to the ability of a bank to make cash payments as the fall due. Liquidity risk might result from a mismatch between the size and the maturity of assets and liabilities in a bank's balance sheet. For instance, if a bank is not able to meet deposit withdrawals, this might lead to a bank run where depositors rush to withdraw their deposits as a consequence of losing confidence in the bank. This, in turn, might limit the ability of the bank to borrow funds from the interbank market, turning the liquidity crisis of the bank into solvency crisis and possible failure.

To reduce liquidity risk, banks can increase the proportion of liquid assets of cash and marketable securities, such as Treasury bills (T-bills) and other government securities, or fund its operation using longer-term liabilities. However, holding such liquid assets might decrease the profitability of the bank as the rate of return associated with such assets is lower (Casu *et al.*, 2006). Banks with higher liquidity risk (less liquid assets) might be forced to borrow emergency funds at higher rate of return, which in turn increase bank costs and decrease bank cost efficiency. However, because liquid assets yield lower rate of return for the bank compared to other risky assets, such as loans, higher amount of these assets might decrease bank profits and hence its profit efficiency.

2.5.5 Market (or Trading) Risk

Casu *et al*. (2006: 269) define market risk as “the risk of losses in on-and-off- balance sheet positions arising from movements in market prices [and it is particularly related] to short-term trading in assets, liabilities and derivative products, and relates to changes in interest rates, exchange rates and other asset prices.” For instance, a bank might suffer losses resulted from changes in the prices of fixed-income instruments, equity instruments, commodities, currency contracts, or changes in the market indices overall. Greuning and Bratanovic (2009) argue that the major components of market risk are interest rate risk, equity risk, commodities risk and currency risk. Banks must keep up with any changes in the overall market conditions because such changes will affect the overall performance of banks. Rose (1999) discusses as an example that as interest rates increase, the market value of fixed-income securities (e.g. bonds) and fixed-rate loans will fall. Conversely, as interest rates decrease, the market value of the banks’ fixed-income securities and fixed-rate loans will increase, generating capital gains when they are sold, but the bank might suffer losses on its fixed-rate liabilities. Casu *et al*. (2006) refer to the risk associated with unexpected changes in interest rates as *interest rate risk* whose effects depends on whether bank assets and liabilities are fixed rate or rate-sensitive[8]. Value-at-Risk (VAR) analysis is one method that larger banks perform to assess the market risk associated with their trading assets portfolios whereas small banks conduct sensitivity analysis to measure market risk (Casu *et al*., 2006).

2.5.6 Capital Requirements and Bank Risks

Capital acts as a cushion against losses that might result from taking on excessive risks by the bank’s management. To maintain the soundness and safety of banks and keep the financial system stable, financial regulators have paid close attention to the capital adequacy. While banks prefer to operate with less capital so as to maximise the return on equity as banks’ returns depend on risk taken, regulators require banks to increase their capital to keep safer. To reduce bank risks including insolvency risk, credit risk,

[8] For more on interest rate risk, see Casu *et al*. (2006).

liquidity risk and market risk, the Basle Committee has proposed different agreements (known as Basle Accords) that specify minimum capital requirements to be applied by banks. The first was the Basle I Accord that was proposed in 1988 and came into effect in 1992. This accord set a minimum capital equal to 8% of the risk-weighted assets (defined by Tier 1 and Tier 2) to be held by financial institutions so as to address credit risk and the risk of a counterparty defaulting on its obligations. In spite of its simplicity, Basle I Accord was criticised because it only considers credit risk and it uses uniform risk-weight categories, making the capital requirements specified by this accord insufficient to protect banks against risk and maintain the stability of the financial system.

As a consequence of the flaws associated with Basle I Accord, Basle Committee proposed new rules to update Basle I Accord in 1999, the modified version of Basle Accord I after taking significant amendments into consideration was adopted and published in 2004 under the name of Basle II Accord. The aim of Basel II Accord was to adopt more comprehensive sensitive risk-measure that allowed banks to use their own estimates of risk to determine minimum capital requirements. According to Basle II[9], market risk (after amendments in 1996) and operational risk along with credit risk were taken into account and the minimum capital requirement remained unchanged at 8%. Furthermore, two new pillars were added to the first pillar, which is related to the minimum capital requirements (Tier 3 introduced). The first new pillar relates to the supervisory review process where regulators in different countries can take their local conditions into account when applying Basle II rules. The second new pillar is concerned with market discipline where banks are required to disclose more information about their capital and risk [(Hull, 2010) and (Greuning and Bratanovic, 2009)].

The global financial crisis 2007-2009 and the huge losses for banks associated with this crisis raised concerns about the ability of Basle II Accord to prevent losses and strengthen the immunity of banks against financial fluctuations and economic environmental turmoil. As a consequence of the weaknesses revealed in Basle II, the Basle Committee developed Basle III in 2010-2011, aimed at strengthening the

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[9] For more detailed discussion on Basel II, see [Hull (2010) and Greuning and Bratanovic (2009)].

resilience of the banking sector. Basel III strengthens the capital adequacy requirements in terms of quality and quantity and introduces new requirements with regard to bank liquidity and bank leverage (King and Tarbert, 2011). The adoption of Basel III Accord followed a thorough discussion by the G20 leaders in 2008 and 2009 regarding what should be done so as to strengthen and enhance the global financial regulation and supervision as the global crisis hit strongly. The leaders reached an agreement with regard to enhancing capital requirements, discouraging high levels of leverage, introducing better liquidity risk requirements, and developing sustainable frameworks to deal with securitisation, compensation practices, and moral hazards risks (ECB, 2010) [for more on Basle III and its previous versions see Eubanks (2010a), Monroe (2010) and King and Tarbert (2011)].

2.6 World Financial Crisis

In this study the effect of the world financial crisis on bank efficiency and bank stock performance is investigated. Therefore, in this section we briefly discuss the evolution of the world financial crisis, how it started in 2007 in the US market, and the causes that might be behind the occurrence of such a financially severe event. Also, we shed light on the relationship between different kinds of financial risks, such as; insolvency risk, credit risk, and liquidity risk and the world crisis.

2.6.1 Overview of the World Financial Crisis

The world financial crisis has been said to be the most severe global economic disaster in the last 80 years, and some economists, financial analysts, and researchers consider it even worse than the Great Depression in the 1930s. The main source and the trigger for this world crisis that resulted in a severe global recession was the subprime[10] mortgage market that collapsed after the housing bubble burst in the United States in 2007. This caused a financial and economic turmoil that spread globally out of the US economy due to financial integration and economic globalisation around the world. Calverley (2009: 107) states that, “The crisis was a direct result of too much mortgage lending, which went bad when the housing bubble burst.” This financial crisis has not

[10] Subprime loan refers to a loan that is due to its higher probability of default and is considered to be riskier than the normal (prime) loan (Demyankyk and Hasan, 2010).

only driven world stock markets to fall, but it has also caused many financial institutions including large banks to be taken over, merged, nationalised, bailed out, declared insolvent or liquidated. Among those financial institutions is Lehman Brothers, which was the largest investment bank in the US, and was filed into bankruptcy in September 2008 as a result of investing heavily in mortgage-backed securities (MBS) and other collateralised debt obligations (CDOs). Bear Stearns, a global investment bank in the US, suffered big subprime mortgage losses in two of its hedge funds in June of 2007 and was sold later to JPMorgan Chase in 2008. Also, Citigroup was one of the biggest financial services companies in the world before it was bailed out by the US government in 2008 due to huge losses it suffered during the crisis time. Fannie Mae and Freddie Mac, the two largest mortgage finance lenders, were taken into conservatorship by the US Treasury after they failed to maintain adequate capital ratio over the crisis period (Calverley, 2009). In the UK, Northern Rock, a retail and mortgage bank, was nationalised by the U.K. government in 2008 after suffering big losses caused mainly by default of mortgage borrowers on their loans (Eiteman *et al*., 2009).

There has been a range of causes behind the world financial crisis that have been discussed by authors and economists. One main cause that has been criticised for contributing to the global financial crisis by creating very complicated financial instruments is *securitisation*[11], as argued by Mishkin and Eakins (2012), Shin (2009), Martin-Oliver and Saurina (2007), Keys *et al*. (2008), Calomiris (2009), Thomas (2010), and Diamond and Rajan (2009). The high level of *leverage (borrowing)* maintained by financial institutions prior to the crisis, also, has been argued by the US government Accountability Office (2010), Blundell-Wignall and Atkinson (2009), and Carmassi *et al*. (2009) to be a major contributor to the crisis by increasing the risk of bank failure. The *risk of liquidity* faced by financial institutions prior and over the beginning of the crisis time is further discussed to be a major cause of the financial crisis as explained by Brunnermeier (2009) and Diamond and Rajan (2009). The *loose monetary policy* (especially interest rate) that was adopted prior to the financial crisis by monetary authorities in the US and other countries is, according to Taylor (2008),

[11] Kendall and Fishman (2000: 1) define securitisation as “a process of packing individual loans and other debt instruments, converting the package into a security or securities, and enhancing their credit status or rating to further their sale to third-party investors.”

Calomiris (2009), and Brunnermeier (2009), an important participant in causing the crisis. Moreover, the *too-big-to-fail* doctrine that urged many large financial institutions to take on excessive risk (moral hazard) as taxpayers will share that risk with them in bad times is blamed for contributing to the crisis by Zingales (2010) and Calomiris (2009). In addition to the aforementioned factors, other causes of the crisis are the *excessive compensation schemes*, as argued by Blinder (2009), Diamond and Rajan (2009), Caprio *et al*. (2010), and Lang and Jagtiani (2010), *the credit rating agencies*, as discussed by Lang and Jagtiani (2010), Calomiris (2009), and Hunter (2008), and *imprudent government regulations and policies,* as clarified by Calomiris (2009). Other studies that investigate the causes of the world financial crisis are Merrouche and Nier (2010), Eisenbeis (2010), Claessens and Kose (2010), Mishkin and Eakins (2012), and Poole (2010).

Demirguc-Kunt and Serven (2010) argue that actions taken in the US and European countries include inserting huge amount of liquidity, providing assurance to creditors and depositors supported by blanket guarantees, bailout schemes, recapitalisation, and obtaining a large share in financial institutions by governments, in addition to setting provisions of credit to non-financial firms. However, different recommended solutions have been proposed to overcome the problems contributed to the occurrence of the world financial crisis. For instance, Calomiris (2009) suggests regulatory reform procedures that might enhance risk management and banking system to avoid such severe crisis in the furfure. Those procedures are related to developing prudential micro capital regulations by finding efficient instruments to accurately measure assets risk, and also related to adopting capital requirements that are flexible to meet macroeconomic circumstances. Moreover, the author suggests that large complex financial institutions should be required to prepare credible pre-packaged and pre-approved resolution plans to control the problem of too-big-to-fail. Also, the author suggests modification to the terms of issuing housing loans to reduce mortgage default risk and retracing ownership at banks to solve the agency problems that might exists. Lang and Jagtiani (2010), Caprio *et al*. (2010), and Blinder (2009) have proposed solutions to alleviate the negative consequences associated with massive compensation schemes on risk management. While Blundell-Wignall and Atkinson (2009) propose suggestions to reform financial regulations, Carmassi *et al*. (2009) and Zingales (2010) suggest solutions to reduce systematic instability and controlling the bad consequences of the too-big-to-fail doctrine by utilising new reliable capital requirements. Other studies that suggest some solutions to the causes of the crisis are Caprio *et al.* (2010), Diamond and Rajan (2009), Haldane (2009), and Demirguc-Kunt and Serven (2010).

2.6.2 World Financial Crisis and Banking Risks

There is a strong correlation between the world financial crisis and the risk taken by financial institutions by the time of the crisis. The high level of risk taken by banks and other financial institutions led many of those institutions into failure in the US and Europe, in particular. One risk that has been highlighted when investigating the causes and the characteristics of the financial crisis *is insolvency (capital) risk*. As discussed above in this section, banks with higher capital are less risky because capital works as a cushion to absorb losses a bank might encounter on their assets. Therefore, less capital (higher leverage) threatens the existence of a bank by exposing it to higher financial risk. The building up of financial leverage, in spite of the financial regulations, by financial institutions prior to the world financial crisis has contributed to the occurrence of that crisis. A study done by the US Government Accountability Office (2010) argues that leverage ratio of five large broker-dealing holding companies in the US grew from 22 to 1 in 2002 to around 30 to 1 in 2007.

Blundell-Wignall and Atkinson (2009), in their study on the crisis origins and requirements for reform, discuss how leverage increased over the period prior to the financial crisis at US and European banks. They show that the leverage ratio rose to about 40: 1 in European and US investment banks, and to almost 20: 1 in the US commercial banks between 2002 and 2007. This increase in the leverage ratio was accompanied by acceleration in securitisation in the off-balance sheet mortgages, and both actions were results of inefficient financial regulations that allowed financial institutions to arbitrage capital and other requirements. Carmassi *et al*. (2009) emphasise that due to financial innovation (particularly securitisation) the leverage in financial institutions was magnified. That happened by removing risky assets off the balance sheets, by reducing capital requirements using risk alleviation techniques including credit derivatives, and by embedding leverage in the toxic waste (equity tranches) of mortgage-backed securities. In addition, the authors argue that between 1999 and 2007 the aggregate leverage (total credit to GDP) increased by almost 80% in the US and 100% in Europe in the wider economy, and by roughly 40% in the US and 70% in Europe in the financial sectors, and that these high leverage percentages contributed to amplifying the financial crisis.

Another bank risk that has been highlighted as a cause and a main phase of the world financial crisis is *liquidity risk.* Liquidity risk faced by financial institutions before the financial crisis time is highlighted by many studies. One of those studies is one conducted by Brunnermeier (2009) on the liquidity and credit crunch 2007-2008. The author argues that the reduction in funding liquidity, which contributed to the financial crisis by leading to significant stress for financial systems, was caused by the maturity mismatch at financial institutions. The exposure to the maturity mismatch had two forms; the first is liquidity backstops, guaranteed by commercial and investment banks for the off-balance sheet vehicles that were sponsored by those banks. Those vehicles invested in long-term assets and borrowed for short-term periods (e.g. short-term asset-backed commercial papers). In case those vehicles could not raise money from short-term commercial bank papers to meet short-term obligations, commercial and investment banks sponsoring the vehicles would be responsible for bearing the liquidity risk caused initially by investing in the long-term asset-backed securities. The second form of maturity mismatch exposure is the increased reliance of investment banks on the short-term repurchase agreements (repos) causing maturity mismatch on their balance sheets. Brunnermeier (2009: 80) states that, “This greater reliance on overnight financing required banks to roll over a large part of their funding on a daily basis.” Diamond and Rajan (2009) also argue that the short-term debt that attracted financial institutions before the financial crisis was a major cause of it. While investing heavily in long-term securities (mortgage-backed securities) and while they were expecting low interest rate in the future, those financial institutions were actually exposed to liquidity risk as they borrowed with short-term debt. When house prices started to decrease causing mortgage-backed securities values to fall down, those financial institutions, investing heavily in MBSs, found it difficult to borrow even with short-term debts, making them illiquid due to the maturity mismatch problem.

Another important bank risk revealed by the world financial crisis is *credit risk* that large financial institutions’ management took on at high levels prior to the crisis. Many factors contributed to the high level of credit risk at large banks and other financial institutions by the time of the world financial crisis. Among those factors is the process of *securitisation.* Martin-Oliver and Saurina (2007) discuss that while securitisation allows banks to increase liquidity, transfer credit risk, or arbitrage capital requirements, it also increases the banks' revenues from fees obtained by originating and packaging loans subject to the securitisation process. The authors argue that securitisation (originate to distribute) model has the problem of causing the incentives for lenders to appropriately monitor and investigate the creditworthiness of borrowers to disappear as a bank is going to get rid of the credit risk shortly. Thus, banks lower their lending standards when lending mortgages to subprime borrowers, resulting in high credit risk levels. This result is supported by Keys *et al*. (2008) who investigate the linkage between securitisation and screening standards in the subprime mortgage market in the US and find that the impact of securitisation reduces the motivation of lenders to appropriately monitor and screen their borrowers in the mortgage market.

Another factor that might have led to increasing bank credit risk is the *too-big-to-fail* doctrine that urged many large banks to take on excessive risk. Zingales (2010) argues that the moral hazard caused by such a policy does not only take a form of excessive risk that managers of large banks take on, but also the incentive of such large banks to leverage up as they are capable of borrowing at cheap price from creditors who believe that their debtors are protected by government guarantee. The too-big-to-fail is criticised by Calomiris (2009) who emphasises that in addition to the very risky activities that managers of large banks would invest in, "banks that are protected by the government from the discipline of the market place will be too tolerant of bad management, since managerial errors normally punished by failure will be hidden under the umbrella of government protection." (p.72)

The excessive compensation schemes adopted by many financial institutions were a crucial factor in increasing the credit risk and bank risk overall at those institutions. In his paper, which investigates the role of *compensation* in the financial crisis, Blinder (2009) blames what he calls "go-for-broke" incentives that urge bankers to either take on high-risk activities and get exacerbated compensations in case those bets generate high return or otherwise get no bonuses and find new jobs, in such cases, losses are absorbed by people's money. Diamond and Rajan (2009) investigate the negative role of generous compensation schemes in the risk management performance. The authors notice that many of the compensation schemes were paid for short-term risk-adjusted performance that motivated traders at financial firms to take risky activities whose returns appeared, mistakenly, to come from better performance rather than from higher risk premium. However, Diamond and Rajan (2009) argue that risk managers were not ignorant of such incentives provided to risk traders (and enhanced by talent competition between them), but managers might be unable to quantify and control such incentives.

In this thesis, we will be investigating the level of the above three types of risk; insolvency risk, liquidity risk, and credit risk, at banking sectors in the European Union over the period 2004-2010. This allows us to investigate the level of these bank risks before and during the world financial crisis, and also to compare the level of bank risks for the entire EU, the old EU members, the new EU members, and the GIIPS countries. Moreover, the effect of these types of bank risk on bank cost and profit efficiencies and on bank stock returns will be examined. If empirical evidence that banks with lower levels of these bank risks appear to be more efficient during the financial crisis (2007-2009) than their counterparts with higher risk levels, then these banking risks are important factors to control for in order to protect banking performance during times of financial distress. Furthermore, the influence of the world financial crisis on bank cost and profit efficiencies and on bank stock returns will also be considered thoroughly in this thesis.

2.7 Eurozone Debt Crisis

The world financial crisis 2007-2009 has paved the way for another crisis named as the Eurozone Sovereign-Debt Crisis. After the financial crisis and particularly from 2010, the financial markets have been highly affected by concerns regarding the solvency of some European countries. These concerns focus mainly on the sovereign debts in the Eurozone because of the weak performance of the so-called GIIPS [12] countries; namely, Greece, Ireland, Italy, Portugal, and Spain. The Eurozone debt crisis started in Autumn of 2009 when the Greek government revealed a high government deficit level of 12.7%, which is four times higher than the European Rules (3% in the Maastricht Treaty) allow, and high public debt percentage. As a consequence, the investors' confidence eroded, which in turn caused interest rates on government bonds to rise to high levels making it difficult for the Greek government

[12] Some authors, policymakers and analysts refer to these countries as "periphery" countries, but in this thesis we use the term GIIPS.

to borrow at a cheap price. The fear spread quickly to other members of the Eurozone, particularly the GIIPS countries, as they all had budget deficits of GDP higher than the allowed limit and high borrowing percentage. Such financial fears in the Eurozone and the consequences that might appear as a result made the European Union and the International Monetary Fund (IMF) intervene and provide financial assistance packages to those countries facing sovereign-debt problems. As a consequence of the debt crisis, the five GIIPS countries have been threatened by severe recession and their government bonds have had junk ratings, BBB+ or lower by Standard & Poor's, which makes it difficult for them to sell large amount of bonds to finance their deficit or to roll over a large public debt [Nelson *et al*. (2012) and Arellano *et al*. (2012)].

According to Nelson *et al*. (2012), the Eurozone crisis was a consequence of a combination of challenges some of which faced the Eurozone countries together and others which were specific to each country. The authors argue that capital inflows and the following accumulation of public and private debt over the past decade into the GIIPS states contributed to the crisis. As those countries prepared to adopt the Euro, interest rates on their bond fell so as to converge with that of stronger economies of the Eurozone, such as Germany. Thus, public and private sectors of the GIIPS countries were able then to borrow more cheaply as they accessed new cheap credit, but they did not use such capital efficiently in productive investments that could generate enough money to repay their debts, which in turn increased debt levels. Also, capital inflow increased prices and the overall inflation in the GIIPS countries, leading to a decrease in their competitiveness with other Eurozone countries. As a result, these countries had a deficit in their trade balance, forcing them to borrow and increase their debts. Nelson *et al*. (2012) discuss that Greece had a poor management of public finance with high levels of tax evasion as well as high government spending on public sector jobs and benefits. With regard to Ireland, the budget deficit rose to over 30% as a consequence of government guarantee and bailout of Irish banks, while the Portuguese economy faced a problem of strengthening its competitiveness and was progressing very slowly compared to the other Eurozone countries prior to the world crisis. Spain, on the other hand, had budget surplus and low public debt prior to the world crisis, however, capital inflows contributed to an unsustainable housing bubble. As to Italy, this country has a long-term high public debt and tried to pay high wages while having an under-competitive economy, leading to a budget deficit crisis.

Neri and Ropele (2013) argue that there is no solid evidence that the sovereign debt crisis has macroeconomic effects on euro area as a whole and on individual countries. Moreover, the authors argue that this crisis has led to an increase in the cost of new loans and a contraction in credit which in turn caused negative effect on industrial production in the GIIPS and other Eurozone countries. Furthermore, Allen and Moessner (2012) point out that the lending capacity of banking systems in the euro area has been much weakened as a consequence of the sovereign debt crisis. In addition, the authors argue that the euro crisis has created internationally liquidity stresses.

In this thesis, we utilised the Eurozone crisis by focusing on the performance of the five GIIPS countries over the study period. We make an EU sub-sample of the GIIPS countries to see how their cost and profit efficiency levels can be compared to that of other EU groups. In addition, the three types of banking risk discussed above in this chapter will be investigated to see what level they have prior to and during the world financial crisis in these countries.

2.8 Summary and Conclusion

This chapter presents a theoretical framework concerning productive efficiency. Inefficiency of a firm is measured as the deviation from a "best-practice" frontier where totally efficient firms operate. Economic efficiency can be divided into technical and allocative efficiency. Technical efficiency refers to the ability of a firm to obtain the maximum level of outputs given a set of inputs, or the ability of a firm to minimise input use in the production given a set of outputs. Allocative efficiency reflects the ability of a firm to use the optimal proportion of inputs given their respective prices and production technology. Technical efficiency can be decomposed into pure technical and scale efficiency. Moreover, this chapter defines cost and revenue efficiencies when information on input prices and output prices, respectively, are available. Economies of scale refers to increasing firm scale that leads to falling long-run unit costs, while economies of scope exist when the total costs of producing two or more products jointly is less than the total costs of producing those products separately or independently.

This chapter also reviews five (non-parametric and parametric) frontier approaches that can be used to measure firm efficiency. The non-parametric approaches are mathematical programming approaches that do not allow for noise when measuring efficiency and hence consider all deviations from the frontier as inefficiency. The parametric approaches, on the other hand, allow for noise when measuring efficiency but they need a pre-specified functional form for the efficient frontier and the efficiency distribution. The non-parametric approaches include data envelopment analysis and the free disposal hull, while the parametric approaches include the stochastic frontier analysis, distribution free approach, and thick frontier approach. While there is no consensus as to what frontier method is preferred for measuring banking efficiency, the stochastic frontier analysis (SFA) and data envelopment analysis (DEA) are the most widely used efficiency frontier methods among the others discussed above.

In addition, this chapter introduces an overview of different risks banks face and explains the conventional trade-off between risk and returns. Insolvency risk, credit risk, liquidity risk, and market risk are among the most important risks banking systems encounter, and financial regulators monitor the reduction of these by setting up capital requirements specified, mainly, in Basle Accords. These banking risks might affect cost and profit efficiencies as this chapter explains. As the world financial crisis hit financial systems and global economy severely, this chapter sheds light on the characteristics, causes and suggested solutions of this crisis as well as investigating the relationship between bank risk levels and the crisis and how all that might have influenced banking efficiency. Finally, this chapter briefly provides an overview of the Eurozone sovereign-debt crisis that hit some Eurozone countries, particularly the GIIPS countries.

Chapter 3

The Structure and Regulatory Environment in the EU Banking System and Selected Literature on Banking Efficiency and Risk

3.1 Introduction

During the last two decades the integration process has been accelerated in the European banking markets. The multiple forces of financial deregulation, the foundation of the Economic and Monetary Union (EMU) and the introduction of the euro have contributed to that integration. Along with deregulation, the technological change has played a part in the progressive process of integration and increased competition in the banking industry (European Central Bank [ECB], 2010b). This in turn increased the importance of bank efficiency improvement whether in terms of reducing costs or increasing profits.

The banking systems of the European Union (EU) member states; the old and the new states, have faced big challenges with regard to financial regulations. Regarding the old EU countries, the Second European Banking Directive and the single European Passport played a key role in deregulation and eliminating market entry barriers between those countries. This resulted in a higher level of competition and a unified banking market. The combined effects of the euro introduction, information technology advancement, and the benefitting of new investors from a global capital market fostered the competition and consolidation of the European banking system. The new EU countries, on the other hand, underwent major reforms and transformations during the 1990s. They moved from the centralised planned economic system and mono-banking system towards more liberalised financial and banking markets. In addition, the banking sectors in those countries became more developed due to the flow of foreign capital, market integration, and the establishment of an efficient regulatory framework (Hollo and Nagy, 2006).

This chapter aims to shed light on the main changes in European banking structure and financial regulations that the European Union has gone through in order to create more unified and stabilised banking systems. It, also, reviews the empirical literature on banking efficiency and banking risk, mainly in European countries. The remainder of this chapter is structured as follows. In section 3.2, we shed light on the regulation and structure of the EU banking system. For instance, Section 3.2.1 discusses the process of deregulation and re-regulation in the European banking markets and the related legislative changes since the late 1970s. Section 3.2.2 covers the introduction of the European Monetary Union (EMU) and the adoption of the Euro as a single currency as well as the stages and the conditions related to them. Section 3.2.3 explores the structure of the European Union banking sectors using five indicators and what changes take place between 2004 and 2010. The Eastern enlargement process of the European Union together with the transition process which the EU accession countries have gone through, are introduced in section 3.2.4. Section 3.3 reviews literature on European banking efficiency in which different frontier methods are adopted to measure bank efficiency in different European countries. Section 3.4 presents the literature review on risk in European banking and the association between banking risk and efficiency. Finally, section 3.5 provides a summary and conclusion.

3.2 The European Union Banking System: Regulation and Structure

In this section we briefly discuss different issues related to the regulation and structure of the EU banking system. It starts by introducing the processes of deregulation and re-regulation that the EU banking system has gone through. Then, we provide a summary of the establishment of the European Monetary Union (EMU) and the adoption of the euro. Afterward, we discuss the structure of the EU banking system using five structural banking indicators before reviewing briefly the Eastern Enlargement of the European Union.

3.2.1 Deregulation and Re-regulation in European Banking Markets

The banking industry is, in general, a heavily regulated economic sector because of the key role banks play to maintain the financial and economic stability of a country. While banks supply credit and smooth the intermediation process and payments system, there is potential systemic "contagion" risk resulting from bank runs and market failures that stem from asymmetric information problems, externalities, and market power problems (Van Damme, 1994). To protect the financial and the banking systems, and hence the entire economy of a country against such risks, bank prudential regulations, supervisions, and monitoring programmes should be established so as to ensure the stability and soundness of the financial system. In addition to systemic stability, such prudential regulations would also protect consumers and investors against high prices and opportunistic behaviour of banks, as well as achieving social goals (Llewellyn, 1999).

In Europe, until the 1980s, financial sectors were mainly regulated and oriented by governments to protect banking sectors against crises where rather significant institutional differences were found among individual European countries. However, the internationalisation and globalisation of financial markets together with the transformation of the world economy unified the European views towards the liberalisation of trade and cash flows across borders as well as the adoption of the market-oriented economy. Therefore, the deregulation process started to take place in order to pave the way for more liberalised and free financial and banking markets in European countries. Structural deregulation refers to the process of breaking the regulations that controlled financial institutions in the past. Gardener (1991) argues that the main economic aim of the process of structural deregulation was to achieve economic gains from the allocation of resources by creating a free liberalised market and not by the control of central governments. Moreover, Berger and Humphrey (1997) argue that deregulation is implemented to improve the performance of the industry being deregulated. They add that if efficiency increases, the improvement in the allocation of resources would benefit the society in terms of reducing prices and expanding services if competition is sufficient.

The European Union financial and banking markets have experienced different legislative changes to enhance the process of financial and banking re-regulation since the late 1970s. In 1977, the EU First Banking Co-ordination Directive was adopted which aimed to build a foundation for bank authorisation and supervision by removing some obstacles to the provision of services and opening new branches across borders within the EU. Although this directive created some financial coordination among banking authorities with the EU, it failed to entirely remove the barriers and to create a free market. In 1985, the White Paper on Completing the Internal Market, which was followed by the Single European Act (1986), was the main and important step towards obtaining the objective of the Single European Market (SEM) in 1992. According to the White Paper, all physical, technical and fiscal barriers in addition to the obstacles regarding the movement of goods, capital, services, and people had to be removed by 31 December 1992.

The Second Banking Co-ordination Directive was adopted in 1989 in which it introduced the Single EU banking license and the principles of home country control and the mutual recognition that were produced as guidelines earlier in the White Paper. According to Molyneux *et al*. (1996), the Second Banking Directive provided for compatibility of minimum capital standards for banking authorisation, supervisory control of major shareholders, suitable accounting and control techniques, and standards and own funds, solvency ratio and legislation of protection. Since the Second Banking Directive was adopted in 1989, different other Directives have been adopted by the European Commission. For instance, the Money Laundering Directive (1993) was adopted in order to prevent money laundering by forcing financial institutions to meet some obligations, the Investment Services Directive (1993) to provide a single passport for investment services and the Directive on Deposit Guarantee Schemes (1994) to set a minimum guaranteed investor protection in the event of bank failure. Also, the Consolidated Banking Directive (2000), Financial Conglomerates Directive (2002) and New EU Takeover Directive were adopted.

With regard to the re-regulation of banking supervisory, adopting modern and more effective supervision instruments was crucial in the EU banking markets, especially after the significant increase in the risk level maintained by banks and other financial institutions in the 1980s. To ensure the safety of the banking system, capital adequacy became the pivotal issue with regard to bank prudential re-regulation (Molyneux *et al*., 1996). Gardener (1992) argues that the importance of capital adequacy stems from the idea that the regulation of capital adequacy increases as banking risks increase and the capital adequacy has a main objective of maintaining the stability of the banking system. For these reasons, the Basel Committee on Banking Supervision in 1988 issued Basel I Accord was forced by law in 1992 in G-10 countries. The committee developed Basle II in 2004 as a consequence of the weaknesses that Basle I suffered, while Basle III was introduced afterwards in 2010-2011 to strengthen the resilience of the banking sector and the overall economic stability, as discussed in the previous chapter.

3.2.2 European Monetary Union and the Adoption of the Euro

The European Monetary System (EMS), which was established in 1979, and the Single European Act (1986) paved the way towards a more integrated monetary system in Europe. In the late 1980s, the concerns about the monetary and economic stability in European countries increased, which increased, in turn, the need for a more integrated and unified monetary system. As a consequence, the Delors committee finished a report on the European Monetary Union (EMU) in which the process of creating the EMU was clarified (El-Agraa, 2000).

In 1991, a summit by the members of the European Community was held in Maastricht where the members adopted essential amendments to the original Treaty of Rome (1957), and the decision was to introduce the European Monetary Union (EMU) and to adopt the Euro as a single currency by 1 January, 1999. There was a three-stage timetable for the EMU to be implemented where the first stage began on 1 July 1990 and member states had to intensify their economic co-operation between their central banks and with regard to the free movement of capital through their borders. The second stage began on 1 January 1994 during which the European Monetary Institute (EMI) was created as a preparatory step towards the creation of the European Central Bank (ECB), which was established in 1998. In this stage, the economic convergence and monetary policies co-ordination between the member states were intensified so as to pave the way towards the establishment of the EMU and the single currency (Euro). The conditions to participate in the economic and monetary union and the Euro were clarified in the Maastricht Treaty (signed on 7 February 1992) and can be summarised, according to El-Agraa (2000), as follows:

1. Price stability: where prices in the member states must not exceed by more than 1.5 percentage points that of the three best performing EU member states.
2. Interest rate: where long-term interest rate must not exceed by more than 2 percentage points that of the three best performing member states in terms of inflation.
3. Budget deficit: where member states are required to maintain a budget deficit that does not exceed 3% of the Gross Domestic Product (GDP).

4. Public Debt: where the ratio of public debt to GDP must not exceed 60%.
5. Currency stability: where the fluctuation margin of exchange rate for the last two years before the examination must be within the band provided by the exchange rate mechanism of the EMS without devaluation at the member state's own initiative.

The third stage for the EMU began on 1 January 1999 where the euro as the single currency of the EU member states was introduced and the common monetary policy became under the supervision of the European Central Bank (ECB). In May 1998, 11 European nations passed the test to participate in the EMU; namely, Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Spain, and Portugal. Moreover, Greece did not satisfy the criteria, Sweden failed to meet the conditions with regard to the Exchange Rate Mechanism (ERM), and the UK and Denmark decided not to proceed with EMU in 1999. The number of European countries that joined the EMU has increased recently to 18 with the inclusion of seven extra countries, namely; Cyprus, Estonia, Malta, Latvia, Slovakia, Slovenia, and Greece. These 18 European countries are referred to currently as the Eurozone or euro area.

3.2.3 European Banking Structure

The forces of deregulation, integration, technological changes, privatisation, financial liberalisation, and the enlargement of the European Union have brought about significant changes into the structure of the European banking sectors. Over the period 1985-2004, Goddar *et al*. (2007) observe significant changes in the structure of the EU15 (old EU states) banking sectors. There was a fall in the number of banks, a significant increase in the total assets of banking sectors, an increase in the number of branches, an increase in the number of banking employees, and a non-consistent trend in the concentration ratio. These changes, according to the authors, might have reflected the financial deregulation, integration, and the adoption of the single market program.

In this section, we shed light on the changes in the banking sector structure in the 27 EU countries over the period 2004-2010. Tables 3.1 and 3.2 below report five structural banking indicators; namely, number of banks, number of employees of banks, total assets of banks, number of branches, and the five-bank concentration ratio for total assets, for the old EU members (EU15) and the new EU members (EU12) as well as for the entire EU region (EU27)[13]. Data regarding these five structural banking indicators are collected from the ECB's banking sector structures publications and Datastream database. With regard to the number of banks, the total number of banks fell between 2004 and 2010 from 7224 to 6809 in the EU15 area, from 1678 to 1391 in the EU12 area, and from 8902 to 8200 in the EU27 region. Ireland experienced a large increase (511%)[14] in the number of banks compared to the other old EU states, which shows a contraction in the number of banks over time, with the exception of Belgium and Greece. Estonia shows the largest increase in the number of banks (100%) among the new EU states, while Cyprus shows the largest decrease in the number of banks (-63%). Furthermore, it can be noticed that the percentage decrease in the number of banks is higher between 2004 and 2007 that it is during the period 2007-2010 in all the three EU groups. The total decrease in the number of credit institutions in the EU overall can be attributed to the consolidation process; particularly, mergers and acquisitions (M&A) which increased after 2004. The number of M&A transactions in the European banking sectors peaked in 2006 and reached a high value in 2007, while it dropped in 2008 to increase, again, in 2009; probably as a consequence of the financial crisis 2007-2009 (ECB, 2010a; ECB, 2008).

With regard to the employees of banks, the banking sector employment between 2004 and 2007 increased by 3% on average in the EU15, by 18% in the EU12 and by 5% in the EU27. However, employment decreased significantly by 22% in the EU15 while it increased by only 2% in the EU12 averaging a 19% decrease in the overall employment in the EU region between 2007 and 2010. This significant decrease particularly in the EU15 might be attributed to the job cuts and employee layoffs that took place during global financial crisis.

Concerning the assets of banking sectors, the tables show significant increase in the total banking assets in the EU between 2004 and 2010 especially in the new EU states

[13] EU15 refers to the 15 old EU countries that joined the EU before 2004 and include Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, and the United Kingdom; EU12 refers to the 12 new EU countries that joined the EU in 2004 and 2007 and include Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, and Slovenia; and EU27 refers to all the 27 EU countries both the old and the new member states.

[14] The significant increase in the number of banks in Ireland was due to the reclassification that took place in 2009 (ECB, 2010a).

(153%) compared to the old EU states (43%). This significant rise in the total banking assets in the EU can be attributed to the financial integration, liberalisation, and free flow of capital between the EU member states and other liberalised financial markets, as well as the single market programme that put an end to the repressed banking systems (Dermine, 2006). Despite the financial crisis the total assets of banking sectors in the EU27 did not decline, rather it increased from 2004 to 2008 until that increase halted in 2009 (ECB, 2010a). Although total assets increased during the crisis time in the EU27 (5%), the increase was much larger in the period prior to the crisis (37%).

The number of branches rose by 5% in the EU15 and by 37% in the EU12, and by 9% in the entire EU over the period 2004-2010. However, within the old EU member states the trend of this indicator is not consistent as some countries show a decrease in the number of branches, whereas other members show an increase in branches with France showing the largest increase of almost 48%. On the other hand, the majority of the new EU states observe increases in the number of branches, particularly Romania (104%), with the exception of Cyprus, Estonia, and Slovenia.

The tables also show mixed numbers with regard to the concentration ratio (measured as the ratio of total assets of the largest five banks) in the EU member states. While the change in the concentration ratio of the EU15 banking sectors over the seven-year period is, on average, +4%, it is negative at -2% in the new EU members, and the total average change for the EU27 is positive at +1%. This might be surprising and does not stand in line with the tendency towards de-concentration and competition enhancement in recently deregulated and liberalised banking systems in the EU. However, as Maudos and Fernandez de Guevara (2004) and Carbo and Fernandez (2005) argue, the increasing tendency towards concentration in the non-traditional banking business might have redeemed the tendency towards de-concentration in the traditional banking business (i.e. loan business). Also, in the entire EU region concentration increased only in the period prior to the crisis and the reason behind this might be the merger and acquisition transactions that increased between 2004 and 2007 (ECB, 2008).

Table 3.1. Structural Financial Indicators for the EU15 Banking Sectors:

Country	Number of banks						Employees ('000s)						Assets (billion euros)						Number of Branches						Concentration % (CR5)					
	2004	2007	2010	*Change %*			2004	2007	2010	*Change %*			2004	2007	2009	*Change %*			2004	2007	2010	*Change %*			2004	2007	2010	*Change %*		
				04-07	*07-10*	*04-10*				*04-07*	*07-10*	*04-10*				*04-07*	*07-09*	*04-09*				*04-07*	*07-10*	*04-10*				*04-07*	*07-10*	*04-10*
Austria	796	803	780	*1*	*-3*	*-2*	73	78	78	*7*	*1*	*7*	635	891	1037	*40*	*16*	*63*	4360	4266	4171	*-2*	*-2*	*-4*	44	43	36	*-2*	*-16*	*-18*
Belgium	104	110	106	*6*	*-4*	*2*	71	67	62	*-6*	*-8*	*-13*	914	130	1156	*-86*	*790*	*26*	4837	4425	4087	*-9*	*-8*	*-16*	84	83	75	*-1*	*-10*	*-11*
Denmark	202	189	161	*-6*	*-15*	*-20*	46	50	48	*8*	*-5*	*3*	630	978	1105	*55*	*13*	*75*	2119	2194	1654	*4*	*-25*	*-22*	67	64	64	*-4*	*0*	*-4*
Finland	363	360	338	*-1*	*-6*	*-7*	25	25	23	*-2*	*-6*	*-8*	212	288	388	*35*	*35*	*83*	1585	1693	1475	*7*	*-13*	*-7*	83	81	84	*-2*	*3*	*1*
France	897	808	686	*-10*	*-15*	*-24*	440	497	…..	*13*	….	…..	4419	6682	7156	*51*	*7*	*62*	26370	39560	38958	*50*	*-2*	*48*	49	52	47	*5*	*-8*	*-4*
Germany	2148	2026	1929	*-6*	*-5*	*-10*	712	691	668	*-3*	*-3*	*-6*	6584	7562	7424	*15*	*-2*	*13*	45331	39777	39494	*-12*	*-1*	*-13*	22	22	33	*0*	*48*	*48*
Greece	62	63	62	*2*	*-2*	*0*	59	65	63	*9*	*-2*	*7*	231	383	490	*66*	*28*	*113*	3403	3850	4005	*13*	*4*	*18*	65	68	71	*4*	*4*	*9*
Ireland	80	81	489	*1*	*504*	*511*	36	42	36	*18*	*-13*	*3*	723	1337	1324	*85*	*-1*	*83*	909	1158	1162	*27*	*0*	*28*	46	50	57	*10*	*13*	*24*
Italy	787	821	778	*4*	*-5*	*-1*	336	340	320	*1*	*-6*	*-5*	2276	3332	3692	*46*	*11*	*62*	30950	33230	33640	*7*	*1*	*9*	26	33	39	*25*	*18*	*48*
Luxembourg	162	155	146	*-4*	*-6*	*-10*	23	26	26	*16*	*1*	*16*	695	915	798	*32*	*-13*	*15*	253	229	…..	*-9*	….	…..	34	31	31	*-10*	*1*	*-9*
Netherlands	461	341	290	*-26*	*-15*	*-37*	118	114	108	*-3*	*-6*	*-9*	1678	2168	2217	*29*	*2*	*32*	3798	3604	2864	*-5*	*-21*	*-25*	84	86	84	*3*	*-2*	*1*
Portugal	197	175	160	*-11*	*-9*	*-19*	53	61	62	*15*	*1*	*16*	345	440	520	*27*	*18*	*51*	5371	6055	6460	*13*	*7*	*20*	67	68	71	*2*	*4*	*7*
Spain	346	357	337	*3*	*-6*	*-3*	246	276	261	*12*	*-5*	*6*	1717	3005	3433	*75*	*14*	*100*	40603	45500	43164	*12*	*-5*	*6*	42	41	44	*-2*	*8*	*6*
Sweden	212	201	174	*-5*	*-13*	*-18*	44	49	50	*10*	*3*	*13*	600	855	935	*43*	*9*	*56*	2018	1988	1937	*-1*	*-3*	*-4*	54	61	58	*12*	*-5*	*6*
UK	407	390	373	*-4*	*-4*	*-8*	507	506	455	*0*	*-10*	*-10*	7085	10095	9421	*42*	*-7*	*33*	13902	12425	12276	*-11*	*-1*	*-12*	35	41	43	*18*	*4*	*23*
EU15	*7224*	*6880*	*6809*	*-5*	*-1*	*-6*	*2791*	*2887*	*2261*	*3*	*-22*	*-19*	*28744*	*39062*	*41093*	*36*	*5*	*43*	*185809*	*199954*	*195347*	*8*	*-2*	*5*	*54*	*55*	*56*	*3*	*2*	*4*

Source: Datastream Database and ECB Publications

Table 3.2. Structural Financial Indicators for the EU12 Banking Sectors:

Country	Number of banks						Employees ('000s)						Assets (billion euros)						Number of Branches						Concentration % (CR5)					
				Change %						*Change %*						*Change %*						*Change %*						*Change %*		
	2004	2007	2010	*04-07*	*07-10*	*04-10*	2004	2007	2010	*04-07*	*07-10*	*04-10*	2004	2007	2009	*04-07*	*07-09*	*04-09*	2004	2007	2010	*04-07*	*07-10*	*04-10*	2004	2007	2010	*04-07*	*07-10*	*04-10*
Bulgaria	35	29	31	*-17*	*7*	*-11*	22	31	34	*39*	*10*	*53*	13	31	38	*136*	*22*	*187*	5606	5827	5961	*4*	*2*	*6*	52	57	55	*8*	*-3*	*6*
Cyprus	405	215	152	*-47*	*-29*	*-63*	11	11	13	*7*	*12*	*19*	47	93	139	*100*	*50*	*200*	977	921	911	*-6*	*-1*	*-7*	57	65	66	*13*	*1*	*15*
Czech Republic	70	56	58	*-20*	*4*	*-17*	39	40	38	*3*	*-4*	*-1*	87	140	160	*61*	*14*	*84*	1785	1862	1990	*4*	*7*	*12*	64	66	62	*3*	*-5*	*-3*
Estonia	9	15	18	*67*	*20*	*100*	5	6	6	*40*	*-13*	*23*	9	21	21	*140*	*3*	*149*	203	266	202	*31*	*-24*	*-1*	99	96	92	*-3*	*-4*	*-6*
Hungary	217	206	189	*-5*	*-8*	*-13*	36	42	42	*18*	*-1*	*17*	…..	109	126	*....*	*16*	*.....*	2987	3387	3493	*13*	*3*	*17*	53	54	55	*3*	*1*	*4*
Latvia	23	31	31	*35*	*0*	*35*	10	13	12	*32*	*-10*	*20*	11	31	30	*175*	*-3*	*168*	583	682	587	*17*	*-14*	*1*	62	67	60	*8*	*-10*	*-3*
Lithuania	74	80	91	*8*	*14*	*23*	7	10	10	*41*	*-3*	*38*	9	24	26	*177*	*10*	*206*	758	970	951	*28*	*-2*	*26*	79	81	79	*3*	*-3*	*0*
Malta	16	22	26	*38*	*18*	*63*	3	4	4	*9*	*5*	*16*	21	38	41	*82*	*9*	*98*	99	105	113	*6*	*8*	*14*	79	70	71	*-11*	*1*	*-9*
Poland	744	718	700	*-3*	*-3*	*-6*	150	174	185	*16*	*6*	*23*	142	234	274	*65*	*17*	*94*	8301	11607	13518	*40*	*16*	*63*	50	47	43	*-7*	*-7*	*-13*
Romania	40	45	41	*13*	*-9*	*3*	50	66	67	*33*	*1*	*34*	23	72	86	*211*	*20*	*272*	3031	6340	6170	*109*	*-3*	*104*	60	56	53	*-5*	*-6*	*-11*
Slovakia	21	26	29	*24*	*12*	*38*	20	20	18	*0*	*-8*	*-8*	31	58	55	*89*	*-6*	*77*	1113	1169	1224	*5*	*5*	*10*	67	68	72	*3*	*6*	*8*
Slovenia	24	27	25	*13*	*-7*	*4*	12	12	12	*3*	*0*	*3*	25	44	53	*78*	*23*	*118*	706	711	694	*1*	*-2*	*-2*	65	60	59	*-8*	*0*	*-8*
EU12	*1678*	*1470*	*1391*	*-12*	*-5*	*-17*	*363*	*429*	*439*	*18*	*2*	*21*	*416*	*893*	*1051*	*115*	*18*	*153*	*26149*	*33847*	*35814*	*29*	*6*	*37*	*65*	*66*	*64*	*0*	*-2*	*-2*
EU27	*8902*	*8350*	*8200*	*-6*	*-2*	*-8*	*3154*	*3316*	*2701*	*5*	*-19*	*-14*	*29160*	*39955*	*42144*	*37*	*5*	*45*	*211958*	*233801*	*231161*	*10*	*-1*	*9*	*59*	*60*	*60*	*1*	*0*	*1*

Source: Datastream Database and ECB Publications

Figure 3.1 below shows the trend of each of the five structural banking indicators for the three groups; the EU15, the EU12, and the EU27, on average over the period 2004-2010. It can be seen that the three EU groups exhibit fairly descending trends in the number of banks especially between 2004 and 2007 with the number of banks being significantly higher in the EU15 than in the EU12. Regarding the number of bank employees, the trend rises for all groups from 2004 to 2007, while it declines significantly for the EU15 and the EU27 after 2007. Furthermore, Figure 3.1 shows an increase in the total assets of banks over the period 2004-2010 particularly between 2004 and 2007 for all country groups. However, the magnitude of this increase is larger for the old EU countries than it is for the new EU countries. In addition, the graph shows a rise in the number of branches until 2007, while it shows a slight fall for the EU15 afterwards. Finally, the trend of concentration shows a decent increase for the EU15 over time, while the EU12 exhibits a slight decline during the period 2007-2010.

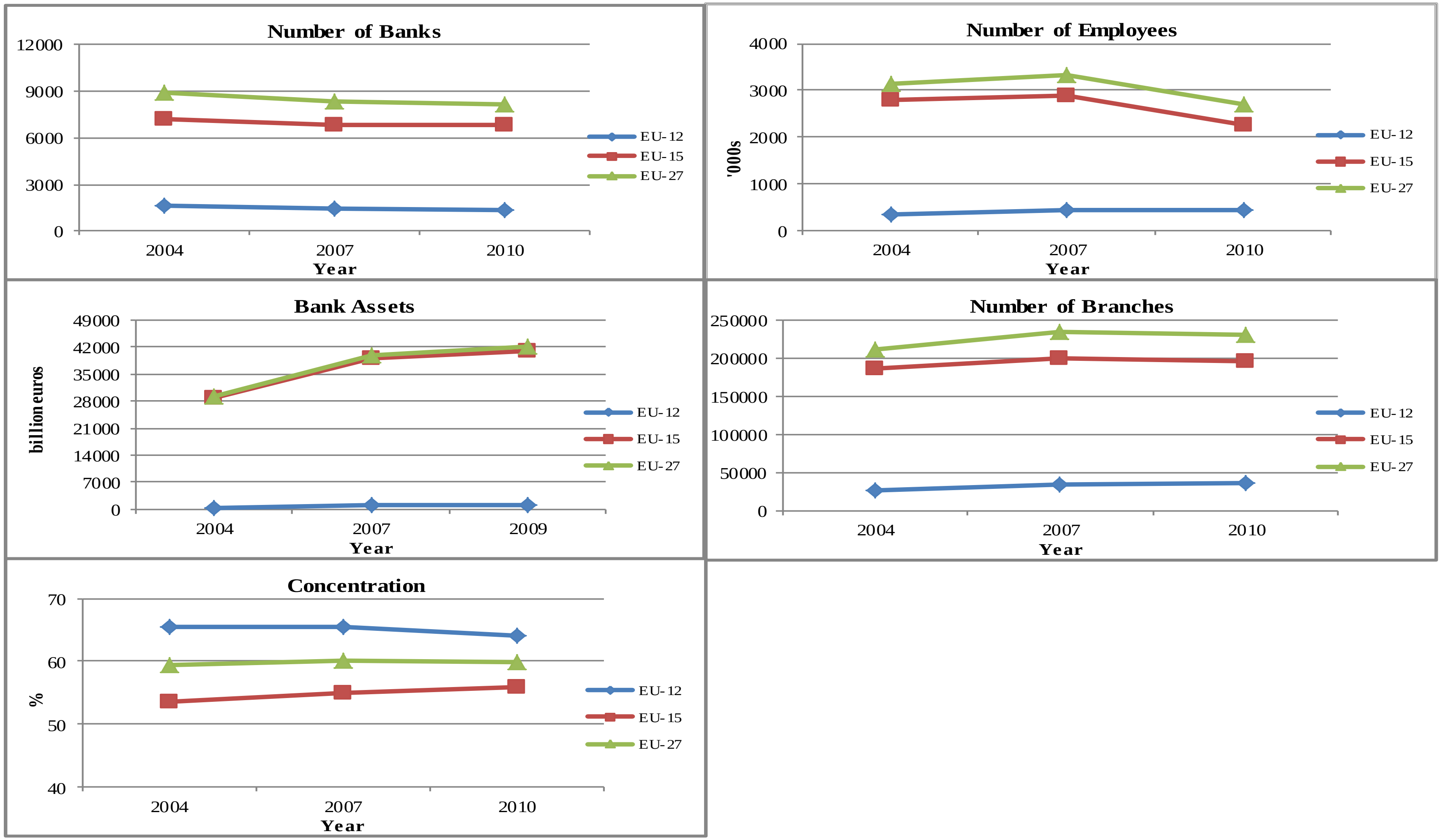

Figure 3.1. Structural Banking Indicators in the EU (2004-2010)

3.2.4 The Eastern Enlargement of the European Union

The establishment of the European Union dates back to 1952 when six countries, namely; France, West Germany, Italy, Netherlands, Belgium, and Luxembourg founded the European Coal and Steel Community (ECSC) by signing the Treaty of Paris on 23 July 1952. The Treaty of Paris was followed by the Treaty of Rome (1957) when the six countries agreed to create the European Economic Community (EEC) and the European Atomic Energy Community (EAEC). The European Coal and Steel Community (ECSC), the European Economic Community (EEC) and the European Atomic Energy Community (EAEC) were merged in 1967 to form what is called the European Community (EC). The first Western European Enlargement was in 1973 at which time three countries, the United Kingdom, Denmark, and Ireland joined the European Union. Greece joined the European Union in 1981 as the second (Southern or Mediterranean) EU enlargement, which was followed by the third EU enlargement that took place in 1986 when two additional European countries, Spain and Portugal, joined the EU. Austria, Finland, and Sweden formed the fourth EU enlargement when they joined the European Union in 1995 (O'Brennan, 2006).

After the adoption of the Maastricht Treaty in 1992 in which the EMU conditions were set up, as explained earlier above, the European Council laid down the EU membership rules at Copenhagen Summit in June 1993, these rules were named as Copenhagen criteria. Central and Eastern European (CEE) states are eligible to join the EU if they meet the Copenhagen criteria, which according to European Council (1993) state that:

> "Membership requires that the candidate country has achieved stability of institutions guaranteeing democracy, the rule of law, human rights and respect for and protection of minorities, the existence of a functioning market economy as well as the capacity to cope with competitive pressure and market forces within the Union. Membership presupposes the candidate's ability to take on the obligations of membership including adherence to the aims of political, economic and monetary union."

According to the Maastricht Treaty, for joining the European Union, an accession country requires the agreement of each current individual EU members in addition to the European Parliament. As a consequence of these legislative criteria, eight Central and Eastern European countries joined the EU in 2004, these countries include Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia, and Slovenia, as well as two Mediterranean countries, Cyprus and Malta, forming what is called the Fifth EU enlargement. Bulgaria and Romania completed their European Union memberships in 2007 while Croatia joined the EU recently in 2013 and became the last members to join the EU so far, leaving the door open for other countries to join the EU. According to the aforementioned enlargements, the EU countries can be classified as the old EU member states that includes the 15 European countries that joined the EU before 2004 (EU15), and the new EU member states that includes the countries that completed their EU membership in 2004 and 2007 (EU12)[15].

In the last two decades, the new EU states (transition countries) have gone through significant economic and political transformation in order to meet the transitional process criteria launched by the EU in March 1998 for the joining the European Union. These transformations range from rapid financial development and a high economic growth to improving the legislations with regard to banking and financial supervision in a way that helps the new EU countries to economically catch up with the old EU states (Staikouras and Koutsomanoli-Fillipaki, 2006). The new EU countries, also, restructured their banking sectors by implementing the two-tier banking system so as to separate the function of central bank and commercial banks as well as permitting privatisation (Weill, 2003a). In more detail, the International Monetary Fund (IMF) (2000) refers to the main components of the economic transition process which includes:

- The liberalisation of economic and financial markets in a way that allows prices to be determined in free markets in addition to removing the trade barriers between the EU countries.

[15] Croatia can also be classified as a new EU country; however, in this study we focus on the other 12 new EU countries as Croatia recently joined the EU in 2013 and hence it is excluded in our study.

- Enhancing the macroeconomic stability via controlling inflation rate, government budget, and the growth of money and credit.
- Enhancing the financial and banking sectors by allowing restructuring and privatisation of enterprises.
- Finally, the implementation of legal and institutional reforms to organise the state role in these economies, build solid law rules, and create suitable competition policies.

3.3 Literature Review on European Banking Efficiency

In the last two decades, research on the efficiency of financial institutions has received wide attention. Studies on bank efficiency have been conducted on several countries and regions, addressing several issues in different time periods and using different methods and tools to estimate efficiency. Berger and Humphrey (1997) survey 130 studies that measure financial institutions' efficiency using frontier methods in 21 countries around the world. Those studies adopt different parametric and non-parametric frontier methods (discussed in Chapter 2) to estimate bank efficiency. They, also, focus on different types of financial institutions, such as banks, credit unions and insurance firms. It can be noticed from the survey that efficiency of financial institutions in the US maintains the largest bunch of those studies, while the majority of the rest focus on single or small groups of countries. Fethi and Pasiouras (2010) also review 179 studies where data envelopment analysis (DEA) is by far the most commonly used technique to measure bank performance in those studies. Molyneux *et al*. (1996) argue that there is a need for good European research and this need stems from the importance of European financial sectors in acquiring the overall economic benefits resulting from deregulation and free market allocation of resources.

Bank efficiency studies, in general, vary in the objectives they seek to achieve. While some studies aim to explain the effects of deregulation, integration, liberalisation, bank failures and market structure on efficiency, other studies provide cross-border efficiency comparisons or focus on issues such as risk and stability over time. This section discusses the empirical studies on bank efficiency and focuses mainly on the studies conducted on European Union countries. We start by surveying some of the comparative efficiency studies in the EU region and then we provide a summary of some studies that relate bank efficiency to some issues, such as integration, ownership, and consolidation. We leave the studies that relate bank efficiency to risk and stock returns to the next sections.

3.3.1 Comparative Efficiency Studies in the EU Banking Markets

Hollo and Nagy (2006) aim to estimate bank efficiency differences across the EU countries and explain their causes. The authors adopt the stochastic frontier approach (SFA) to estimate both X-efficiency[16] (cost efficiency) and alternative profit efficiency of 2459 banks operating in 25 EU member states over the period 1999-2003. Two models are used in this study; one does not control for country-specific variables while the other does. The aim for including environmental variables in the second model is to reduce the distorting effect of size and other operational bias on the estimation of efficiency.

Hollo and Nagy (2006) find that, based on the uncontrolled model, the average bank cost efficiency of the 25 EU countries is 85%. Also, bank cost efficiency in the old EU states is, on average, significantly higher than the efficiency in the new EU states over the investigated period. However, there is a clear catching up in the new member states over time as cost efficiency increases significantly and the efficiency gap with the old member countries decreases. On the other hand, when environmental variables are controlled in the efficiency model, the results are similar except that the cost efficiency gap between the old and the new EU countries is much smaller over the time period. Regarding profit efficiency, according to the uncontrolled model the authors find that the average profit efficiency for the entire EU region is 69%. Also, there is no significant difference between average profit efficiency scores in the old and the new EU countries, with the latter being slightly more efficient. In contrast, according to the controlled model banks in the old EU member states show slightly higher profit efficiency, on average, than banks in the new member states, though the efficiency gap slightly decreases.

[16] X-efficiency concept was first proposed by Leibenstein (1966). It combines both allocative and technical efficiencies and it measures “how well management aligns technology, human resource management, and other resources to produce a given level of output” (Kablan, 2010: 5). In banking efficiency literature, X-efficiency and cost efficiency are used interchangeably. [For more on X-efficiency, see Leibenstein (1966)].

Berg *et al*. (1993) investigate banking efficiency in three Nordic countries, namely Sweden, Finland, and Norway, in1990, both on national and on pooled data sets using the technique of data envelopment analysis (DEA). Berg *et al*. (1993) find that the efficiency spreads between banks are most important in Finland and Norway and least important in Sweden, according to the individual country results. Based on the pooled sample, the results show that the largest Swedish banks are among the most efficient banks in the sample, whereas only one large Finnish bank and no large Norwegian bank have efficiency scores above 90%.

An international comparison concerning operational bank efficiency is implemented by Allen and Rai (1996). The study investigates input inefficiencies and output inefficiencies using a global cost function for 194 commercial banks operating in 15 international countries (nine EU countries included) over the period 1988-1992. The stochastic frontier approach (SFA) and the distribution-free approach (DFA) are applied to generate estimates for X-inefficiency. The results suggest that input inefficiencies outweigh output inefficiencies and that the distribution-free approach overestimates X-inefficiency scores compared to the stochastic frontier approach. Furthermore, Allen and Rai (1996) find that large banks in the countries that prohibit the functional integration of commercial and investment banks exhibit the largest measure of input inefficiencies that amount to 27.5% of total costs. On the other hand, the X-inefficiency levels for all the other banks are around 15% of total costs.

Using the Fourier flexible functional form [17] together with stochastic cost frontier, Altunbas *et al*. (2001a) measure X-inefficiency, scale economies, and technical change for 15 European countries over a nine-year period of time (1989-1997). The results show that scale economies range between 5% and 7%, whereas X-inefficiency scores are found to be higher and range between 20% and 25%. Moreover, X-inefficiencies show greater differences across markets, bank sizes and over time than scale economies. In addition, Altunbas *et al.* (2001a) find that technical progress has a positive influence in reducing

[17] The Fourier-flexible (FF) functional form is a semi-nonparametric approach and it is a global approximation that was first introduced by Gallant (1981, 1982). Fourier flexible functional form is used in banking efficiency studies as an alternative to the translog functional form for the estimation of bank efficiency.

bank costs by almost 3% over time and this reduction increases with bank size. The authors conclude that European largest banks benefit most from technical progress even though no scale economy advantages are observed compared to the smaller banks.

Similar to Altunbas *et al.* (2001a), Carbo *et al.* (2002) investigate X-inefficiency and scale economies of the banking systems in European countries using the flexible Fourier functional form together with stochastic cost frontier. However, this study focuses only on measuring efficiency and scale economies of only savings banks operating in 12 EU member states over the period 1989-1996. The study shows that scale economies range between 7% and 10% and positively correlated with bank size. On the other hand, X-inefficiencies are found to be larger (around 22%) and not significantly related to bank size. Carbo *et al.* (2002) conclude that savings banks in Europe can reduce their costs by reducing managerial and other inefficiencies and also by increasing the production scale.

Lozano-Vivas *et al.* (2002) adopt a data envelopment analysis (DEA) approach to investigate banking operating efficiency from an input-oriented view in European market. The authors aim to investigate bank technical efficiency of 10 Western European countries in the year 1993 using two models – one does not account for environmental variables (basic model) while the other does. According to the DEA basic model with a common efficiency frontier, the results indicate that banks in Luxembourg are the most efficient, leaving banks in Spain and Portugal at the other extreme with the lowest efficiency score. On the other hand, applying the complete model, that takes environmental variables into consideration, results in Spain having the highest average efficiency score, while the lowest score is Italy. In general, Lozano-Vivas *et al.* (2002) observe that there is a significant increase in the average efficiency score in almost all countries when controlling for the environmental variables, meaning that those variables exercise a strong influence over the behaviour of each country's banking industry.

Maudos *et al.* (2002a) examine cost and profit efficiencies of 832 banks operating in ten European Union countries over the period 1993-1996. Four parametric panel data approaches are employed for the purpose of estimating efficiency; stochastic frontier analysis, distribution free approach, fixed effects model, and random effects model. The study shows that the average cost efficiency for the whole sample is 82.7% according to the DFA, with banks in Finland, Italy, and France are the least cost efficient, whereas Austrian banks are found to be the most cost efficient banks in the sample. Moreover, the random effects model (REM) generates cost efficiency score of 83.9%; while lower cost efficiency score is obtained (76.9%) using the fixed effects model (FEM). According to the two methods, Austria, again, and Germany are the most cost efficient while Finland is on the opposite extreme with the lowest level of cost efficiency. As to the alternative profit efficiency, the results indicate that profit efficiency scores, in general, are lower than those of cost efficiency using the three methods above, suggesting that the most important inefficiencies are on the revenue side. The authors further investigate possible efficiency correlates and find that medium-sized banks are more cost and profit efficient while banks with higher risk and banks operate in more concentrated markets appear to be more profit efficient and less cost efficient.

Grigorian and Manole (2002) investigate commercial bank efficiency in seventeen transition countries over the period 1995-1998 using the Data Envelopment Analysis model. In addition, the study evaluates through a regression analysis the impacts of different environmental variables relating to bank-specific features, macroeconomic environment, regulatory environment, and general business environment on efficiency. Grigorian and Manole (2002) find that on average commercial banks in Central Europe (CE) operate more efficiently than banks in the South-Eastern Europe (SEE) countries and in the Commonwealth of Independent States (CIS). The authors also conclude that foreign ownership with controlling power and enterprise restructuring has a positive influence on bank efficiency. Furthermore, commercial banks that attain higher market share are found to be more efficient than those with small market share, and consolidation is found to positively affect the efficiency of banking operations.

Weill (2003a) makes a comparison between bank efficiency in Eastern and Western EU countries. In his study, Weill (2003a) measures bank cost efficiency for 11 Western and 6 Central and Eastern European countries (CEE) in years 1996 and 2000. Employing the stochastic frontier approach to measure efficiency, the results show that banks in Western European countries exhibit higher efficiency levels than their counterparts in the CEE region. This means that there is a gap in cost efficiency between banking systems in the two regions; however, this gap is reduced between the years 1996 and 2000 for 4 Eastern countries. To see whether this gap can be explained by differences in environment, Weill (2003a) includes different environmental variables in the cost frontier estimate. He concludes that the efficiency gap between the Western and Eastern European countries is hardly explained by differences in environment or risk preferences, meaning that the efficiency gap can be attributed to weak managerial performance at Eastern European banks.

Kasman and Yildirim (2006) analyse cost and profit efficiency of European banks. They adopt the SFA to obtain cost and profit efficiency scores of 190 commercial banks operating in eight Central and Eastern European countries for the period 1995-2002. The study, also, examines the impact of different country-specific variables along with foreign ownership on bank inefficiency by employing the Battese and Coelli (1995) one-step SFA model. The results show that the average cost inefficiency for the whole sample is 20.7% while the average profit inefficiency stands at 36.7%. In addition, the results suggest that banking systems in all countries in the sample are more cost efficient than being profit efficient, indicating their higher ability to control costs than making profits. Kasman and Yildirim (2006) conclude that bank cost and profit inefficiencies differ across countries and across different bank size groups, and they find some evidence that foreign banks are, on average, more efficient than domestic banks.

In contrast to Kasman and Yildirim (2006), Yildirim and Philippatos (2007) use two-step models to investigate cost and profit efficiency and their correlates of banking systems in 12 Central and Eastern European transition countries over the period 1993-2000. The parametric approaches of SFA and DFA are used to estimate efficiency scores of 325 commercial and cooperative banks. The study shows that average cost efficiency level for the 12 countries estimated by the SFA and DFA is 77% and 72%, respectively. On the other hand, profit efficiency levels appear to be lower than those of cost efficiency, as also concluded by Kasman and Yildirim (2006) and Maudos *et al.* (2002a), and stand at 66% and 51% based on the SFA and DFA, respectively. With regard to the correlate of bank efficiency, Yildirim and Philippatos (2007) find that bank size and capital have a positive effect on bank efficiency, while competition is found to affect positively cost efficiency and negatively profit efficiency. Furthermore, foreign banks appear to be more cost efficient and less profit efficient compared to domestically-owned private banks and state-owned banks.

A recent study on bank efficiency in the European Union is one carried out by Kosak *et al.* (2009). The authors examine bank cost efficiency in eight new EU member states that joined the EU in 2004; five of which are located in Central and Eastern Europe in addition to three Baltic States. Based on SFA technique, the study results show that the average cost efficiency score for the whole sample is almost 88%, and banks in the three Baltic countries are more cost efficient than their counterparts in the other five EU member states. Furthermore, the results reveal an improvement in the average cost efficiency of the eight countries over the ten-year period of time which, according to Kosak *et al.* (2009), can be attributed to the process of accession to the EU and the regulatory reforms and institutional changes associated with it for the new EU countries. Moreover, the authors examine the effects of different country specific, industry specific, and bank specific variables on cost inefficiency. The authors conclude that competition level in the banking sector is more important for improving cost efficiency than the ownership structure itself.

Other than the bank efficiency comparative studies discussed above, many efficiency studies focus on estimating efficiency of a single banking sector in Europe. For instance, Drake (2001) investigates efficiency and productivity change in the UK banking market over the period 1984-1995 using the DEA technique, and they find important evidence of the relationship between efficiency and size in the UK banking sector. Using the DEA technique, Maudos *et al.* (2002b) examine the importance of specialisation in explaining Spanish bank efficiency over the period 1985-1996. They find that accounting for the effect of different bank specialisation by estimating separate frontiers, improves the relative efficiency of banking companies. Canhoto and Dermine (2003) analyse efficiency of banks in Portugal by employing DEA over the period 1990-1995 taking the differences in efficiency between old and new banks into account. The study results show an improvement of overall efficiency over time and find new banks to be more efficient than old banks. A study conducted by Halkos and Salamouris (2004) sheds light on the commercial banks' performance in the Greek banking market over the period 1997-1999 using standard financial ratios along with the DEA approach. The results show a positive relationship between efficiency and bank size and that the increase in efficiency is associated with a decrease in the number of small banks due to mergers and acquisitions. Girardone *et al.* (2004) have carried out a study on the determinants of cost efficiency in the Italian banking sector using the SFA over the period 1993-1996. They find that cost inefficiency range between 13% and 15% and that inefficiency is related positively to the level of non-performing loan and negatively to capital strength. Finally, Matousek and Taci (2004) have conducted a study on cost efficiency of the banking sector in the Czech Republic in the 1990s using the distribution-free approach in the 1990s. They find that foreign banks are more efficient than other banks and that early privatisation of state-owned banks and more liberal policy in the early stage of transition would have improved bank efficiency.

To sum up, the aforementioned studies compare banking efficiencies between different members of the European Union using different frontier methods over different time periods. In general, studies that compare banking efficiency between the old (Western) EU countries and the new (Eastern or transitional) countries find that the former is more efficient than the latter, suggesting that an efficiency gap between the two groups of countries still exists. Also, overall, these studies find that different micro and macro-economic factors might help explaining differences in banking efficiencies between banks and across countries.

3.3.2 Bank Efficiency, Integration, Ownership and Consolidation

As discussed above, bank efficiency studies address different issues in different areas using different methods; among those issues is the relationship between bank efficiency and integration, ownership or consolidation. Among the studies that examine the effect of integration on bank efficiency is that of Tomova (2005). The author employs data envelopment analysis (DEA) to measure bank efficiency and convergence in the old EU member states, 10 new member states and three associated countries during the period 1994-2002. The results show lack of convergence and persistently various levels of bank efficiency. However, there is a decrease in the variability of efficiency scores and sigma convergence of banking efficiency across Europe, which is biggest in magnitude in 1996 and after the introduction of the EMU in 1999.

Similar to Tomova (2005), Mamatzakis *et al.* (2008) have conducted a study on bank efficiency and possible efficiency convergence across new EU countries. The authors adopt the SFA to estimate bank cost and profit efficiencies of 10 new European Union member states for the period 1998-2003. In addition to low levels of cost and profit efficiency, the results show evidence of convergence in cost efficiency across the new members, while no evidence of convergence in profit efficiency is found. Another study that sheds light on efficiency convergence as an indicator of financial integration in the European Union is the one carried out by Weill (2008). Along with measuring cost efficiency using the SFA, the study aims to investigate to what degree banking integration has been accomplished by considering convergence in bank cost efficiency in ten old EU member states over the period 1994-2005. The results show dispersion in bank efficiency across countries while there is an improvement in cost efficiency levels over the investigated time period. Moreover, Weill (2008) finds an evidence of convergence in cost efficiency between the EU countries' banking systems meaning that financial integration has taken place between the EU banking markets over the study period. Casu and Girardone (2010) carried out a study on integration and convergence in bank cost efficiency in fifteen EU member states over the period 1997-2003. Using the DEA to estimate cost efficiency, the authors find no evidence of an overall improvement of cost efficiency levels towards the best practice. Notwithstanding, there is an evidence of cost efficiency convergence towards the average efficiency of the EU countries.

The association between banking efficiency and ownership in Europe has also been investigated in many studies. For example, Weill (2003b) conducts a comparative study on the cost efficiency of domestic-owned and foreign-owned banks located in two transition countries; Czech Republic and Poland in 1997 using the SFA technique. The findings show that foreign-owned banks are, on average, more cost efficient than domestic-owned banks in 1997; however, this cannot be attributed to the differences in activities structure or scale of operations. Moreover, one of the studies that comprehensively shed light on the impact of ownership on banking efficiency is the study conducted by Bonin *et al.* (2005). The authors attempt to examine the relationship between banking efficiency and ownership in 11 European transition countries over the period 1996-2000 by adopting the Stochastic Frontier Approach (SFA) to estimate efficiency. The study results show that privatisation does not improve bank efficiency and foreign-owned banks are found to be more cost efficient than other banks. Another study that measures the linkage between different kinds of ownership and bank efficiency is Fries and Taci (2005). The SFA is used to measure cost efficiency for 289 banks in 15 Eastern European countries over the period 1994-2001. The results reveal that banking systems in which foreign-ownership has a larger share of total assets are more cost efficient, meaning that foreign-ownership of banks is associated with higher levels of cost efficiency. Furthermore, the authors find that state-owned banks appear to be less efficient than private-owned banks, especially those private banks with majority foreign ownership. By investigating bank efficiency in Poland using the Data Envelopment Approach (DEA) and ownership, Havrylchyk (2006) finds that greenfield (foreign) banks are more efficient than takeover (foreign) and domestic banks, whereas state-owned banks are superior to other domestic banks in the Polish banking industry.

With regard to the relationship between bank efficiency and consolidation, Vander Vennet (1996) measures the performance effects of merger and acquisition (M&A) between banks in 10 EU countries over the period 1988-1993. Using the SFA to estimate bank efficiency, the results show that domestic mergers of equal-sized banks increase the performance of the merged banks and that cross-border acquisition improve cost efficiency. Resti (1998) also investigates the effect of M&A on bank efficiency in the Italian banking market. Using the DEA method, he finds an increase in the cost efficiency of merged banks in the years after the merger, particularly when the deal takes place between banks operating in the same local market, and when the size of the new institutions is not too big. Pawlowska (2003) examines the effect of M&A on bank efficiency, scale efficiency, and productivity change in the Polish banking sector over the period 1997-2011. By employing the DEA to estimate efficiency, the author finds that M&A has a significant and positive effect on bank efficiency measures and productivity indices. Beccalli and Frantz (2009) investigate the influence of M&A on bank cost and profit efficiencies estimated using the SFA in the EU over the period 1991-2005. They find that M&A is associated with a slight decrease in bank profit efficiency over the study period and an improvement in cost efficiency.

In summary, different studies attempt to compare bank efficiency between different European countries; Eastern and Western European countries, old and new EU countries and developed and emerging European countries. Also, different studies examine the effect of some financial issues; such as integration, ownership and consolidation on bank efficiency in Europe. However, there is a lack of studies that compare all the 27 EU countries during the period following the year 2004; where 12 new countries join the EU. This study fills this gap by making a comparison of both bank cost and profit efficiencies between the old and the new EU member states from the year 2004 until 2010. This will provide an overview on the performance of the new EU countries after the financial transformation they went through and joining the EU compared to the old EU countries both in terms of cost minimisation and profit maximisation. Moreover, we extend this comparison by measuring bank efficiency for a sample of the five GIIPS countries that have faced sovereign debt crisis to see how banks perform in such countries with comparison to the other EU member states over the period 2004-2010. In other words, we construct four efficiency frontiers for four samples; namely, the entire EU, the old EU countries, the new EU countries, and the GIIPS countries, and make comprehensive efficiency comparisons between them.

3.4 Literature on Risk in European Banking

Due to the financial and economic changes that have taken place in the last two decades, banking systems in the world, particularly in North America and Europe, have faced the challenge of operating efficiently in such competitive markets and dealing with possible excessive risk-taking. In this section we review briefly some empirical studies that examine the relationship between the efficiency of banks and different sorts of risk that a bank might encounter. Furthermore, we review some studies that investigate bank risk from different perspectives in the European markets.

3.4.1 Bank Efficiency and Risk

The deregulation and financial innovation in the last two decades have made the banking industry larger, more complex, and globally integrated and dependent on the developments in financial markets. The deregulation and technological change that contributed to the integration of European banking markets not only highlighted the importance of banks being operating closer to the best practice frontier, but also the importance of controlling the excessive risk taken by banks due to competition and other economic and financial factors. This competition urged banks to search for sources of income other than the typical interest income that declined because of the increasing competition in banking activities. The tendency of banks towards benefiting from non-interest income to overcome competition generated serious concerns regarding the risk associated with such non-interest activities[18] (Fiordelisi *et al*., 2011).

Different studies attempt to examine the relationship between efficiency and risk in the European banking markets. For instance, Berger and De Young (1997) employ Granger-causality techniques to examine the relationship between loan quality and cost efficiency for US commercial banks over the period 1985-1994. They use the SFA technique to estimate cost efficiency and the ratio of non-performing loans (bad loans) to measure credit risk. The results show a negative relationship between cost efficiency and bank risk, and this negative relationship can be attributed, according to the authors, to two different hypotheses. The first hypothesis is called the "bad management" hypothesis according to which increases in non-performing loans (credit risk) are followed by increases in the costs spent on monitoring, working out or selling off these loans, leading to lower levels of cost efficiency. The "bad luck" hypothesis is the second hypothesis to explain the adverse relationship between efficiency and credit risk. It refers to the idea that bad loans might arise due to adverse economic events that are beyond the bank's control, so that banks would face higher expenses to deal with such loans. However, according to a another hypothesis called the "skimping" hypothesis, there is a positive relationship between bank efficiency and credit risk in the short run as a bank chooses not to spend

[18] Non-interest income is income obtained from sources other than interest income, such as income from trading and securitisation, investment banking and advisory fees, brokerage commissions, venture capital, and fiduciary income, and gains on non-hedging derivatives.

sufficient resources on analysing loan applications. But such a bank bears the consequences of dealing with high problem loans and the associated expenses in the future (Berger and De Young, 1997).

A study that investigates the relationship between efficiency, risk, and capital in the European banking sector is carried out by Altunbas *et al*. (2007). A sample of different types of banks operating in 15 European countries over the period 1992-2000 is used to conduct this study. Using the SFA to measure bank inefficiency, the results do not show a positive relationship between bank inefficiency and risk. In addition, Altunbas *et al*. (2007) find a positive relationship between bank capital and risk; particularly in the case of commercial and savings banks, possibly suggesting the preference of regulators for capital as a means of restricting high-risk activities. With regard to bank capital, inefficiency appears to have a positive effect on capital in the case of savings banks and a negative influence in the case of cooperative, most efficient and least efficient banks. Finally, concerning bank cost inefficiency, capital is found to affect positively inefficiency in all banks except for the cooperative least and most efficient banks, where the effect is negative.

Similarly, Fiordelisi *et al*. (2011) investigate the inter-temporal relationship between bank efficiency, capital, and risk in European commercial banking sector prior to the recent global financial crisis. The authors use Granger-causality techniques to investigate such relationships using panel data framework and a sample of commercial banks operating in 26 European Union countries over the period 1995-2007. Using several definitions of bank efficiency, risk and capital, the results show that lower bank cost and revenue efficiencies Granger-cause higher bank risk. Furthermore, improvements in cost efficiency are caused by increases in bank capital, meaning that moral hazard incentives are reduced with higher capital ratio, which in turn indicates that better capitalised banks are more likely to reduce their costs as opposed to less capitalised banks. Moreover, Fiordelisi *et al*. (2011) find that cost and profit efficiencies positively Granger-cause bank capital, suggesting that more efficient banks become better capitalised in the future. On the other hand, the authors find only limited evidence of relationships between risk and capital suggested by moral hazard hypothesis.

Radic *et al*. (2012) analyse the relationship between bank efficiency and risk-taking in the pre-crisis investment banks. They use a sample of investment banks operating in the G7 countries along with Switzerland to estimate bank cost and profit efficiencies using the SFA technique for the period 2001-2007. Four types of bank risk are taken into consideration in this study; namely, capital risk, liquidity risk, security risk, and insolvency risk. Radic *et al*. (2012) find that not accounting for environmental variables can significantly bias efficiency scores of investment banks, particularly in the case of profit efficiency. When risk variables are included in the frontier models, all of them are found to have a significant effect on bank cost efficiency. While capital risk and security risk have a positive effect on efficiency, liquidity risk and insolvency risk have negative effects. In the case of profit efficiency, only liquidity risk and security risk have a significant effect on profit efficiency, while the prior risk has a negative effect, the latter has a positive influence on profit efficiency. Finally, when the Battese and Coelli (1995) model is used, the results show that capital risk and liquidity risk show a positive and significant effect on cost efficiency, whereas they affect significantly and negatively profit efficiency.

In brief, the aforementioned studies attempt to examine the relationship between banking efficiency and different types of banking risk, including capital, credit and liquidity risk. Overall, it appears that the relationship between these types of risk and banking efficiencies is important and not accounting for banking risk when measuring efficiency might generate misleading results regarding banking efficiency estimates. These results highlight the importance of considering banking risk when estimating efficiency between banks and across countries.

3.4.2 Banking Risk in the EU

In addition to the studies discussed above which investigate the relationship between bank efficiency and risk, other studies examine bank risk from different perspectives. Hansel and Krahnen (2007) analyse the relationship between securitisation, represented by European collateralised debt obligations (CDOs), and bank systematic risk using a sample of 187 asset-backed securities (ABS)-transactions from 49 banks over the period 1997-2004. Using banks' equity beta to represent systematic risk, the results show that issuing collateralised debt obligations in order to shift bank credit risk, results in higher level of systematic risk rather than decreasing it. Further, the authors investigate the factors influencing the changes in bank systematic risk (the changes in its value after the issuance of CDO securities from its value before the issuance), and they find that in the case of synthetic transactions systematic risk changes are negatively related to bank equity ratio, bank profitability, and pre-issue level of beta.

Lepetit *et al*. (2008) have conducted a study that emphasises the effect of product diversification (or income structure) on risk in the European banking industry. Specifically, the authors attempt to investigate whether the increasing volume of non-interest income, as opposed to the traditional interest income, is associated with higher or lower levels of risk using a sample of 734 of banks operating in 14 European countries over the period 1996-2002. The results obtained for the relationship between bank risk and income structure reveal a positive influence of diversification on bank risk and insolvency risk. In addition, and particularly for small banks, higher levels of commission and fee activities are associated with higher levels of bank risk and insolvency risk, meaning that diversifying based on commission and fee activities does not help in reducing risk. On the other hand, higher levels of trading activities at small banks are not necessarily associated with higher levels of bank risk; rather it might be associated with lower asset and insolvency risk.

The linkage between bank risk and monetary policy is considered in the literature by Altunbas *et al*. (2009). The authors investigate such a relationship using a large sample of European banks over the period 1999-2005. The model constructed in this study attempts to measure the effect of banking risk along with other independent variables, such as capital, liquidity, and size, on the growth rate in lending to residents. The authors find that bank risk measured by loan-loss provision ration has a negative effect on bank lending growth. This can be attributed to the idea that higher loan-loss provisions are associated with less profit and lower capital, which in turn decreases banks' lending ability to supply new loans. Similarly, the bank risk measure; one-year ahead expected default frequency, is found to have a negative relationship with bank lending supply. In addition, the authors find that low-risk banks are more able to protect their lending from monetary changes as they are more qualified to obtain funding easily compared to high-risk banks.

A recent study that investigates the correlation between securitisation and bank systematic risk is Uhde and Michalak (2010). Using a sample of 592 cash and synthetic securitisation transactions from 54 banks operating in 16 European countries from 1997-2007, the authors find similar results to those obtained by Hansel and Krahnen (2007). They find that the relationship between securitisation and bank risk is positive, particularly for larger banks. Moreover, banks tend to hold the greater part of credit risk to enhance the securitisation process in its beginning stage. Moreover, the results show that the increase in bank systematic risk due to securitisation is more obvious when the pre-securitisation systematic risk is low.

A recent study conducted by Altunbas *et al.* (2011) attempts to investigate the pre-crisis factors affecting banking risk during the financial crisis 2007-2009 utilising different business models. The authors use a large sample of listed banks operating in the European Union and the United States and adopt three measures for banking distress (or risk) ; namely, the likelihood of a bank rescue, systematic risk, and the intensity of resources to central bank liquidity. In terms of capital structure, Altunbas *et al*. (2011) find a negative relationship between the ex-ante capital and bank risk during the financial crisis for all the three measures of risk. The results also reveal that regarding asset structure, size and the ratio of loans to total assets are positively linked to bank risk, while securitisation is negatively related to risk. As to funding structure, customer deposits are negatively related to bank risk, while short-term marketable securities increase the possibility of bank distress occurrence. Moreover, Altunbas *et al*. (2011) find that higher levels of loan growth significantly and positively affect bank risk during the crisis time due to the lax credit standards associated with such loan expansion.

Finally, Haq and Heaney (2009) investigate the changes in bank equity risk after the formation of the Economic Monetary Union (EMU) in 1999 using a sample of share returns for 16 European countries over the period 1995-2006. They conclude that, in general, there is a decline in bank risk for 70% of the Eurozone banks, and similar results are found for idiosyncratic risk and systematic risk. In addition, evidence of a decrease in bank equity risk for a sample of neighbouring non-euro-zone countries is found.

In summary, the studies discussed above investigate the effect of different types of risk; capital risk, credit risk, liquidity risk, etc. on bank efficiency in European countries, while other studies investigate different aspects of bank risks in Europe. Our study contributes to the literature by investigating the level of three types of risk; insolvency risk, credit risk and liquidity risk, and the effect of these risks on bank cost and profit efficiencies in the four EU country samples adopted in this study over the period 2004-2010. This allows us to compare the levels of banks' risk prior to and during the world crisis time and to see how differently these risks affect bank performance in these EU samples. Furthermore and more importantly, as highlighted in Chapter 2, these three types of risk were the main causes of the world financial crisis that led some financial institutions into financial distress. In this study, we examine the effect of these bank risk types on bank performance in terms of minimising cost and maximising profits during the world financial crisis 2007-2009 for the four samples. This allows us to see whether banks with lower levels of risk could absorb the effect of the crisis and perform better than banks with higher levels of risk. If so, then the three types of bank risk are important factors to consider during financial distress time in the EU banking system.

3.5 Summary and Conclusion

This chapter discusses the process of regulation that the European Union banking system has gone through in addition to the main changes in the European Union banking structure. It starts by discussing the deregulation and re-regulation stages and the legislative changes that the EU banking and financial markets have experienced since the late 1970s. Then the chapter discusses the establishment of the European Monetary Union (EMU) and the adoption of the Euro as a single currency in 1999. This chapter, also, examines the changes in the structure of the European Union banking system that have come as a result of different factors; such as deregulation, integration, technological changes and financial liberalisation. Five structural banking indicators, namely; number of banks, number of employees, total assets, number of branches and concentration ratio are examined. The analysis shows that there are substantial changes in these indicators for the 27 EU countries over the period 2004-2010. Furthermore, this chapter outlines the economic and financial conditions specified in the Maastricht Treaty for candidate members to join the European Union under what is called the Eastern enlargement of the EU. Additionally, this chapter reviews empirical studies on European banking efficiency in which different frontier methods, samples and time periods are used. Empirical studies that examine European banking risk and its association with banking efficiency are also reviewed.

Chapter 4

Methodology and Data

4.1 Introduction

In Chapter 2, we discussed different frontier methods that have been used in the literature to measure different firms' efficiencies. Some of those methods are parametric (e.g. SFA) and some are non-parametric (e.g. DEA). We explained also that the stochastic frontier analysis (SFA) is the method to be adopted in this thesis because it allows for random error contrary to the non-parametric approaches. The main objective of this chapter is to describe and explain the methodology used to measure cost and profit efficiencies as well as banking risk in the EU banking system over the period 2004-2010. This thesis adopts the SFA approach for panel data to measure efficiency and it uses financial ratios to measure banking risks. The SFA Battese and Coelli (1995) one-step model along with the translog cost and profit functions are used to generate efficiency estimates and investigate their determinants.

The remainder of this chapter is structured as follows. Section 4.2.1 briefly defines the stochastic frontier analysis (SFA). Section 4.2.2 introduces the stochastic frontier models for panel data. This includes cost frontier models in Section 4.2.2.1 and profit frontier models in Section 4.2.2.2. Section 4.3 presents the financial ratios used to measure three types of bank risk, namely; insolvency risk, credit risk and liquidity risk. Section 4.4 provides dataset description and defines variables for bank efficiency and its determinants. This includes efficiency input and output variables (control variables) and the efficiency determinants (environmental variables or efficiency correlates). Section 4.5 is summary and conclusion.

4.2 Measuring Banking Efficiency

4.2.1 Stochastic Frontier Analysis (SFA)

The stochastic frontier analysis was independently developed by Aigner *et al*. (1977) and Meeusen and van den Broeck (1977) as a parametric frontier method. This method allows for random error and specifies cost, profit, or production functional form using different inputs and outputs as well as potential environmental variables. The SFA uses a composed error model in which inefficiency is assumed to have asymmetric (one-sided) distribution and the random error has symmetric (two-sided) distribution. The logic behind these distribution assumptions is that inefficiency cannot be negative so it follows a one-sided distribution and the noise term follows symmetric (normal) distribution to capture the random effects of the operating environment and other omitted factors. In this sense, the firm's inefficiency can be estimated by taking the conditional mean or mode of the inefficiency term distribution, given the composed error component. However, the flexibility of the SFA functional forms allows for different distributions to be assumed for the inefficiency, such as normal-half normal, the more general truncated normal, exponential, or gamma distributions [Berger and Humphrey (1997) and Kumbhakar and Lovell (2000)]. The SFA approach yields rather robust results when used to measure banking cost, profit, or revenue efficiency compared to other frontier methods, such as data envelopment analysis (DEA). As explained in Chapter 2, the idea on which the frontier methods are based is the construction of the "best-practice frontier" (or efficiency frontier) against which the relative efficiencies of the firms (banks) operating out of that frontier are measured. In other words, banks that operate on the frontier are efficient (take efficiency score of 1 or 100%), while banks operating above (in case of cost efficiency) or below (in case of profit efficiency) the frontier are inefficient (take a value between 0 and < 1). However, it is important to refer here that totally efficient (best practice) banks operate on the frontier in the case of DEA while in the case of SFA such banks operate close to the frontier but not exactly on the frontier due to the technical estimation the two methods follow. This thesis focuses on measuring cost and profit efficiencies for a panel data sample using the SFA method.

4.2.2 Stochastic Frontier Models for Panel Data

Before introducing the stochastic frontier models for panel data, it is essential to shed light on the definition and the general benefits of using panel data. A longitudinal or panel data set is a combination of cross sectional and time series data, meaning that panel data has two dimensions, one for cross-section units and one for time[19]. For instance, cross-sectional units, such as countries, firms, individuals, can be observed over several points of time to generate a panel data set. Panels can be *balanced*, when the cross-sectional units are covered over the same periods of time, or *unbalanced*, when units are observed for different periods of time. According to Hsiao (2006), panel data has different advantages over cross-sectional or time-series data that can be summarised as follows:

- Panel data can generate a more efficient and accurate estimation for the model parameters as panel data include a higher number of degrees of freedom than cross sectional or time series data, and reduce collinearity between independent variables.
- Panel data helps making statistical inference and computations easier in terms of measuring error, analysing non-stationary time series, and when dynamic Tobit models are to be used.
- Panel data is more appropriate to deal with the human behaviour as it allows for testing more complex human hypotheses with the effects of omitted factors being under control.

Baltagi (2005) further discusses that panel data controls for individual heterogeneity and is more efficient in terms of studying the dynamics of adjustment. Moreover, panel data are better than cross-sectional or time-series data in detecting some effects and in testing more complicated behavioural hypotheses as well. On the other hand, the author refers to some shortcomings of panel data, especially those related to data collection, the bias of measurement error, and different selectivity problems[20].

[19] For more detailed and comprehensive discussion on panel data models, refer to Greene (2008).
[20] For more on panel data advantages and disadvantages, see [Baltagi (2005) and Hsiao, (2003)].

Panel data is preferred over cross-sectional data when the SFA is applied because of the problems connected with cross-sectional data that can be solved when using panel data. Those problems, according to Schmidt and Sickles (1984), are related to: 1) the strong distributional assumptions needed for the application of maximum likelihood estimation of the stochastic cost/profit frontier and the separation of inefficiency term from the random noise; 2) the assumption that the inefficiency term must be independent of the regressors, inputs and outputs when using maximum likelihood estimation; and 3) the Jondrow, Lovell, Materov and Schmidt (JLMS) (1982) [21] technique of estimating cost/profit efficiency cannot generate a consistent estimator as $I \rightarrow \infty$ (where I is the number of cross-section units). Kumbhakar and Lovell (2000) argue that each of these problems can be solved when using panel data because including repeated observations on cross-section units (e.g. banks) can be an alternative for the strong distributional assumptions required for the estimation of cost/profit stochastic frontiers and the assumption of the independence of the inefficiency term. Furthermore, using panel data to increase the observations on cross-section units in the sample can generate consistent estimates for cost/profit efficiency.

A production frontier, against which technical efficiency can be measured, can be constructed using input and output quantities. However, constructing cost/profit frontier and measuring the relative cost/profit efficiency needs information on input/output prices. It is important to refer to the idea that the cost/profit efficiency is an overall or economic efficiency that combines both technical and allocative efficiencies. Cost/profit efficiencies can be decomposed into technical and allocative efficiencies to give useful information in some cases using a system of equations, but this is beyond the scope of this study[22]. As highlighted earlier, the stochastic frontier approach (SFA), like other frontier methods, is based on the idea of constructing a “best-practice” frontier against which the relative cost/profit efficiencies of banks can be measured. In this sense, we can define banking cost and profit efficiencies as follows: cost efficiency measures how close a bank’s cost is to what a best-practice bank’s cost would be for providing the same output bundle.

[21]For further details on JLMS and other point estimators, see [Jondrow *et al.* (1982) and Kumbhakar and Lovell (2000)].
[22] Simultaneous-Equation Frontier Models are useful for decomposing cost/profit efficiency that adopt Cobb-Douglas functional form, for further details, see Kumbhakar and Lovell (2000).

Similarly, profit efficiency measures how close a bank's profit is to what a best-practice bank's profit would be for utilising the same input bundle.

4.2.2.1 Panel Data Cost Frontier Models and Specification

The estimation of cost efficiency requires information on input prices, output quantities, and total costs on the use of inputs. As a panel data set of commercial banks operating in the EU region is to be used in this thesis, we can benefit from a panel data cost frontier model for the advantages just mentioned above, leaving cost frontier models of cross-sectional data to be explained in Appendix (1). If cost inefficiency is assumed to be time-invariant, and according to Kumbhakar and Lovell (2000), the log-linear Cobb-Douglas form can be used to introduce the single-output cost frontier model for panel data as follows:

$$\ln TC_{it} = \beta_0 + \beta_y \ln y_{it} + \sum_n \beta_n \ln w_{nit} + v_{it} + u_i \tag{4.1}$$

Where TC_{it} represents the total cost of bank i at time t , y_{it} is the output, w_{nit} are input prices, v_{it} is the two-sided random noise that is independently and identically distributed according to standard normal distribution; $v_{it} \sim iidN(0, \sigma_v^2)$, and $u_i \geq 0$ is the non-negative truncated time-invariant cost inefficiency term that measures the weakness in the cost managerial performance. The two terms v_{it} and u_i are the two components of the composed error term ε_{it} ; $\varepsilon_{it} = v_{it} + u_i$. $\sum_n \beta_n$ =1 is a homogeneity condition of degree +1 in input prices of cost efficiency frontier. The estimation of the cost efficiency model can be done by utilising different estimating techniques, such as the fixed-effects, random-effects, and Maximum Likelihood technique (ML). The first two techniques do not require specific distributional assumptions regarding the inefficiency term, while the ML does. The fixed-effects model can be estimated using the least squares with dummy variables (LSDV) when the random noise v_{it} is assumed to be uncorrelated with the regressors and the inefficiency term is treated as a constant specific to each bank and has no specific distributional assumptions. Applying the fixed-effects model is simple; however, it has a major shortcoming that it cannot separate the variation in time-invariant cost inefficiency from the effects of other time-invariant variables that also vary across banks. If the inefficiency term is assumed to be randomly distributed and uncorrelated with the noise term and the regressors, then we turn to a random-effects model that can be estimated by a two-step generalised least squares (GLS) method. In spite of the ability of the random-effects model to account for time-invariant regressors, its main drawback is that it requires, unlike the fixed-effects model, the inefficiency term be uncorrelated with the regressors. One of the studies that utilises fixed-effects and random-effects model is the one conducted by Maudos *et al*. (2002a), in which the authors adopted such models along with the distribution-free approach (DFA) to estimate cost and profit efficiency of banks in ten European Union countries. On the other hand, the Maximum Likelihood estimation (MLE) is a more widely used technique in the banking efficiency studies in spite of its need for strong distributional assumptions to work efficiently. The three main distributional assumptions associated with the application of Maximum Likelihood estimation (MLE) are:

(i) $v_{it} \sim iidN(0, \sigma_v^2)$

(ii) $u_i \sim iidN^+(0, \sigma_u^2)$

(iii) u_i and v_{it} are distributed independently of the regressors, and of each other.

While Pitt and Lee (1981) benefit from the assumptions of Maximum Likelihood to apply it to panel data efficiency study assuming half-normal distribution, Battese and Coelli (1988) and Kumbhakar (1987) assume normal-truncated specification to be used in panel data studies. Different studies seeking to find out which of the three techniques, fixed-effects, random-effects, and Maximum Likelihood (ML), is preferred to the others have been conducted, such as Gong and Sickles (1989), Gathon and Perelman (1992), Bauer *et al*. (1993) and Bauer and Hancock (1993). These studies proved similar efficiency results, meaning there is no consensus on what approach is preferred. However, according to Kumbhakar and Lovell (2000), the MLE generates more efficient estimates by utilising the distributional assumptions when the independence of factors and regressors matters, and truly the MLE is the most widely used approach in European banking efficiency studies. In any of these estimation models, the cost efficiency of bank i can be measured by the ratio of the minimum cost (C_{min}) necessary to produce that bank's output and the actual cost (C_i):

$$CE_i = \frac{C_{min}}{C_i} = \frac{\exp[f(y.w)].\exp(v_{it})}{\exp[f(y,w)].\exp(v_{it}).\exp(u_i)} = \exp(-\hat{u}_i) \qquad (4.2)$$

To obtain an estimate for u_i to be applied in the above equation so as to generate the cost efficiency score of a bank i, the conditional mean of the inefficiency term can be used given the composed error term $\varepsilon_{it} = v_{it} + u_i$, following Jondrow *et al*. (1982), where the total variance is $\sigma^2 = \sigma_v^2 + \sigma_u^2$. Another point estimator for cost efficiency was proposed by Battese and Coelli (1988). [For more discussion on cost efficiency estimation models and point estimators of cost efficiency, refer to Kumbhakar and Lovell (2000) and Coelli *et al*. (2005)].

The single-output cost frontier model (4.1) introduced above allows for time-invariant cost efficiency, meaning that cost efficiency is assumed to be constant over time and differs across banks. However, different models were proposed to allow for cost efficiency to vary over time in the panel data context. For instance, Cornwell, Schmidt, and Sickles (CSS) (1990) and Kumbhakar (1990) were amongst the first to introduce stochastic frontier models in which efficiency is allowed to vary over time as well as across firms (banks). In this sense, we can rewrite the single-output cost frontier model (4.1) for panel data as follows:

$$\ln TC_{it} = \beta_0 + \beta_y \ln y_{it} + \textstyle\sum_n \beta_n \ln w_{nit} + v_{it} + u_{it} \qquad (4.3)$$

With the only difference between the two models being the cost inefficiency term is time-variant. This model, again, can be estimated using fixed-effects, random-effects, or Maximum Likelihood (ML) approaches. Lee and Schmidt (1993) suggest that u_{it} can be formulated as:

$u_{it} = \beta(t).u_i$ (4.4); where $\beta(t)$ represents a set of time dummies β_t, and the estimation of inefficiency that can be applied in equation (4.2) can be obtained by: $u_{it} = max\{\hat{\beta}_t \hat{u}_i\} - (\hat{\beta}_t \hat{u}_i)$. Battese and Coelli (1992) suggest the following time-varying efficiency model that can be estimated using maximum likelihood technique with equations (4.3) and (4.4):

$$\beta(t) = exp\{-\eta(t - T)\} \qquad (4.5)$$

Where η is the additional parameter that has to be estimated. The model satisfies the conditions: (i) $\beta(t) \geq 0$ and (ii) $\beta(t)$ increases at an increasing rate when $\boldsymbol{\eta} < 0$, decreases at an increasing rate when $\boldsymbol{\eta} > 0$, or remains constant when $\boldsymbol{\eta} = 0$. The cost frontier model (4.3) takes the Cobb-Douglas functional form that accommodates single output; however, to adopt a multiple-output cost frontier model, we need more flexible and efficient functional form than the Cobb-Douglas form. The following section will introduce such a flexible functional form that is more suitable to be used in this study where different input prices and outputs of different commercial banks operating in the EU region are used.

Cost Efficiency Model Specification:

In spite of its simple application, the Cobb-Douglas functional form has some shortcomings that might negatively affect the measurement of cost efficiency in this study. Hesenkamp (1976) argues that the Cobb-Douglas functional form cannot maintain the curvature condition of the output space in case of multiple-output cost frontier. In addition, Coelli *et al*. (2005) refer to the idea that Cobb-Douglas form is less flexible than other forms, such as the translog form, because it is a first-order flexible form compared with the second-order flexible forms. Moreover, the Cobb-Douglas assumes that elasticities are constant, and hence it cannot be applied efficiently in case of variable elasticities. For these reasons and to obtain more robust cost efficiency estimates, the translog (TL) cost function form is adopted in this panel data study.

The translog function form is one of the most widely used functional forms in banking efficiency studies, and was first introduced by Christensen *et al*. (1971, 1973), and it is a generalisation of the Cobb-Douglas functional form. The appropriateness and soundness of using such functional form in our banking efficiency study can be summarised in three advantages. First, it allows for multiple outputs while maintaining the curvature properties of cost/profit functions. Secondly, it provides a second-order Taylor series approximation to cost/profit frontier at the mean of the data. Thirdly, as Kumbhakar and Lovell (2000:

143) state, “it performs the basis of much of the empirical estimation and decomposition of cost [or profit] efficiency based on a system of equations.” However, the translog (TL) function form is not without drawbacks. First, the translog functional form can be considered as a local approximation to cost/profit function and might perform poorly if the behaviour of bank costs/profits is global (McAllister and McManus, 1993). Furthermore, White (1980) argues that the least square of the translog polynomial might be biased of the series enlargement and, also, this form is a local approximation. The other widely used alternative functional form in banking efficiency studies is the Fourier-flexible functional form. The Fourier-flexible (FF) functional form is a semi-nonparametric approach and it is a global approximation that was first introduced by Gallant (1981, 1982), and was discussed later by Elbadawi *et al*. (1983), Chalfant and Gallant (1985), Eastwood and Gallant (1991), and Gallant and Souza (1991). It was used in banking efficiency studies, such as Spong *et al*. (1995) and Berger *et al*. (1997). Compared to the translog functional form, the Fourier-flexible (FF) functional form is more complicated as it contains some trigonometric terms. There is no consensus on which of these two methods generates better results; however, the translog (TL) functional form is to be adopted in this thesis. First, as Hasan and Marton (2003) argue, the Fourier-flexible (FF) functional form needs more truncations of data to be specified. Secondly, according to Berger and Mester (1997), both functional forms generate similar efficiency results and the difference in the estimated mean efficiency between the two forms is insignificant, so both forms are substantially equivalent from an economic point of view.

The translog specification of cost function to be estimated in this study can be written as follows:

$$\ln\left(\frac{TC}{w_3}\right) = \alpha_0 + \sum_{j=1}^{2} \alpha_j \ln\left(\frac{w_j}{w_3}\right) + \frac{1}{2}\sum_{j=1}^{2}\sum_{l=1}^{2} \alpha_{jl} \ln\left(\frac{w_j}{w_3}\right) \ln\left(\frac{w_l}{w_3}\right) + \sum_{k=1}^{3} \beta_k \ln(y_k)$$
$$+ \frac{1}{2}\sum_{k=1}^{3}\sum_{m=1}^{3} \beta_{km} \ln(y_k) \ln(y_m) + \sum_{k=1}^{3}\sum_{j=1}^{2} \delta_{kj} \ln(y_k) \ln\left(\frac{w_j}{w_3}\right) + \varphi_1 lnEQ$$
$$+ \frac{1}{2}\varphi_2 (lnEQ)^2 + \sum_{k=1}^{3} \rho_k \ln(y_k)\, lnEQ + \sum_{j=1}^{2} \tau_j \ln\left(\frac{w_j}{w_3}\right) lnEQ + v_{it}$$
$$+ u_{it} \quad (4.6)$$

Where TC is bank total costs (interest and non-interest expenses), y_k (k =1,…, 3) represents outputs, w_j (j =1,…, 3) stands for input prices. To impose linear input price homogeneity, total costs, and input prices are normalised by the third input price w_3 (the price of borrowed funds). v_{it} is the two-sided random error that captures random fluctuations, and u_{it} is the non-negative cost inefficiency term that captures the degree of weakness in managerial performance and it follows, in this study, a truncated normal distribution (to be explained soon in this section). Cost efficiency is measured by substituting the estimation of inefficiency term in the equation $CE_{it} = \exp(-\hat{u}_{it})$. The cost function in equation (4.6) has to be linearly homogenous in input prices and for the second-order parameters to be symmetric, so the following restrictions must be imposed:

$$\alpha_{jl} = \alpha_{lj}\,,\ \beta_{km} = \beta_{mk}\,, \sum_{j}^{3} \alpha_j = 1, \sum_{j=1}^{3} \alpha_{jl} = 0, \sum_{k=1}^{3} \delta_{kj} = 0 \quad (4.7)$$

The reason behind the inclusion of financial equity ratio EQ in the estimated cost function is threefold. Berger and Mester (1997) argue that, first, managerial risk preference should be accounted for in the cost function as bank managers differ from each other in term of how risk-averse they are. More risk-averse managers will tend to maintain higher level of equity than the cost-minimising level so as to absorb financial shocks, and therefore not controlling for financial capital would penalise such risk-averse managers. Secondly, the inclusion of equity capital helps in accounting for insolvency risk that affect bank costs through the risk premium that must be paid for uninsured debt and through the extra costs related to risk management activities. Thirdly, as an alternative fund to deposits, capital level directly affects costs in the sense that interest paid on debt counts as a cost while dividends paid do not. On the other hand, higher costs are associated with raising equity than raising deposits meaning a negative effect of higher equity on costs. For these reasons, it is objective to consider equity capital when measuring cost efficiency [see Berger and Mester (1997), Mester (1996), Altunbas *et al*. (2000) and Mamatzakis *et al*. (2008)].

Measuring bank efficiency in the method shown above does not provide answers as to the causes of efficiency differences among banks and across countries. The answer to such question, as argued by Berger and Mester (1997), is of some interest to public policy, bank management, and banking studies. Different regulatory, bank-specific, industry-specific, and macroeconomic factors might influence banking efficiency among banks operating in different countries. The widely approach by which the effect of those factors on bank efficiency can be measured is regressing in/efficiency against such variables. This has been done in bank efficiency literature using two methods, the two-stage and one-stage approaches.

According to the two-stage approach, bank in/efficiency estimates are generated in the first stage using one or more of the efficiency techniques described above, and regress such estimates against different efficiency correlates in the second stage. This approach has been adopted by many efficiency studies, such as Allen and Rai (1996), Berger and Hannan (1998), Bonin *et al*. (2005), Berger and Mester (1997) and Hasan and Marton (2003). The two-stage approach has been criticised by Wang and Schmidt (2002) who argue that the assumption that the inefficiency component is independently and identically distributed across banks is violated in the second step of the approach, where the inefficiency estimate is assumed to be dependent on different explanatory variables. Therefore, according to the authors, the efficiency estimates generated in the first step are biased and inconsistent. To overcome such criticism of the two-stage approach, a one-step approach was introduced first by Kumbhakar *et al*. (1991), and was extended by Battese and Coelli (1995) to allow for panel data. The Battese and Coelli (1995) model is adopted in this study because of the methodological advantages it offers to our panel data efficiency study. First, as stated by Kasman and Yildirim (2006: 1082), "it controls for environmental differences across countries and analyses the effects of these variables on estimated efficiency scores [, and] it alleviates several of the anomalies present in the two-step approach." Secondly, it accommodates unbalanced panel data, as in the case of this study, which allows for more observations to be considered (Lensik *et al*., 2008). According to the Battese and Coelli (1995) model, the inefficiency term is assumed to be a function of a set of independent variables (to be introduced in the data and variables section) z_{it} and a vector of unknown parameters to be estimated, γ. Therefore, the inefficiency component in equation (4.6) can be specified as:

$$u_{it} = \gamma z_{it} + w_{it} \tag{4.8}$$

Where w_{it} is the truncation of the normal distribution with zero mean and variance σ^2, such that the point of truncation is $-\gamma z_{it}$, meaning that $w_{it} \geq -\gamma z_{it}$. Therefore, the non-negative inefficiency component follows a truncated normal distribution; $u_{it} \sim N^+(\gamma z_{it}, \sigma_u^2)$, in which the independent variables it depends on play the crucial role to decide the point of truncation, so that the inefficiency term remains positive. The cost efficiency then can be estimated using the equation $CE_{it} = \exp(-\hat{u}_{it}) = \exp(-\gamma z_{it} - w_{it})$. The one-step model or the simultaneous estimation of the cost frontier and its parameters can be solved using the method of maximum likelihood (ML).

4.2.2.2 Panel Data Profit Frontier Models and Specification

Profit efficiency not only requires the minimisation of the production costs, but it also requires the maximisation of revenues. In this sense, measuring banks' profit efficiency can be a better source of information for bank management in terms of evaluating the overall performance of a bank than measuring either cost or revenue efficiency alone. Also, profit maximisation is a superior and more accepted goal for firms' owners than cost minimisation (Berger and Mester, 1999). Therefore, both cost and profit efficiencies are measured in this study so as to achieve a complete assessment of bank performance. Two profit functions can be recognised: the *standard* profit function and the *alternative* profit function, and the decision between these two functions is based on the idea of considering market power or not. Berger and Mester (1997: 899) state that, "standard profit efficiency measures how close a bank is to producing the maximum possible profit given a particular level of input prices and output prices." In other words, the standard profit function assumes that the output markets are perfectly competitive so that banks are output price takers. In contrast, the alternative (non-standard) profit function measures how close a bank is to producing the maximum feasible profits given a particular level of input prices and output quantities. According to the alternative profit function, banks are assumed to have some market power in determining their output prices, or in other words, the perfectly competitive output markets assumption cannot be held. Berger and Mester (1997) argue that the alternative profit function is preferred over the standard profit function when: (1) banking services are not at the same quality level; (2) the assumption that output markets are perfectly competitive is questionable, so that banks have some market power in deciding their output prices they like to charge. Since our sample in this study includes a large set of commercial banks operating in 27 EU member states where the level of competition in markets along with the quality of banking services are different, then the alternative profit function is preferred and is adopted in this thesis. The alternative profit function has been adopted in different European bank efficiency studies, such as Hasan and Marton (2003), Hollo and Nagy (2006), Kasman and Yildirim (2006), Yildirim and Philippatos (2007) and Mamatzakis *et al*. (2008).

The same analysis followed to introduce cost frontier models for panel data can be applied for the profit frontier models. As a best-practice cost frontier has to be constructed, a best-practice profit efficiency frontier has to be specified so that the relative profit efficiencies of banks in the sample can be measured. In this sense, the alternative profit efficiency of bank *i* can be measured by the ratio of the actual profit (π_i) to the maximum feasible profit (π_{max}) that can be achieved by the best-practice banks:

$$PE_{it} = \frac{\pi_i}{\pi_{max}} = \frac{\exp[f(y.w)]\,.\exp(v_{it}).\exp(-u_{it})}{\exp[f(y,w)]\,.\exp(v_{it})} = \exp(-\hat{u}_{it}) \qquad (4.9)$$

The composed error in the profit efficiency case can be written as: $\varepsilon_{it} = v_{it} - u_{it}$, where the inefficiency term has a negative sign because the inefficient banks obtain less profit than the most efficient banks (operating on the profit frontier), and therefore, they deviate negatively from the profit frontier. In other words, banks with lower u_{it} are closer to the most efficient banks located on the profit efficiency frontier, while banks with higher u_{it} can be found further from the profit frontier.

Profit Efficiency Model Specification

The profit efficiency function employs the same set of input prices, outputs, and environmental variables, and hence it follows very similar translog specification as that of cost efficiency's and can be written as follows:

$$\ln\left(\frac{\pi+\theta}{w_3}\right) = \alpha_0 + \sum_{j=1}^{2}\alpha_j \ln\left(\frac{w_j}{w_3}\right) + \frac{1}{2}\sum_{j=1}^{2}\sum_{l=1}^{2}\alpha_{jl}\ln\left(\frac{w_j}{w_3}\right)\ln\left(\frac{w_l}{w_3}\right) + \sum_{k=1}^{3}\beta_k \ln(y_k)$$
$$+\frac{1}{2}\sum_{k=1}^{3}\sum_{m=1}^{3}\beta_{km}\ln(y_k)\ln(y_m) + \sum_{k=1}^{3}\sum_{j=1}^{2}\delta_{kj}\ln(y_k)\ln\left(\frac{w_j}{w_3}\right) + \varphi_1 lnEQ$$
$$+\frac{1}{2}\varphi_2(lnEQ)^2 + \sum_{k=1}^{3}\rho_k\ln(y_k)\, lnEQ + \sum_{j=1}^{2}\tau_j\ln\left(\frac{w_j}{w_3}\right) lnEQ + v_{it}$$
$$- u_{it} \quad (4.10)$$

Subject to:

$$\alpha_{jl} = \alpha_{lj}\,,\ \beta_{km} = \beta_{mk}\,, \sum_{j}^{3}\alpha_j = 1, \sum_{j=1}^{3}\alpha_{jl} = 0, \sum_{k=1}^{3}\delta_{kj} = 0 \quad (4.11)$$

Where the difference between model (4.6) and (4.10) is that the dependent variable in model (4.10) is the bank pre-tax profit, where θ is a constant equals to one plus the absolute value of minimum profits over all banks in the sample so as to allow for taking logarithm of positive numbers and the inefficiency term has a negative sign[23]. As in the case of cost function model (4.6), the inefficiency term in equation (4.10) is dependent on a set of environmental variables, and the maximum likelihood technique is used to

[23] In adding θ this way, we follow Mamatzakis *et al*. (2008), Kasman and Yildirim (2006) and Yildirim and Philippatos (2007).

estimate the parameters for the one-step Battese and Coelli (1995) profit efficiency model. Profit efficiency scores can be generated using the equation $PE_{it} = \exp(-\hat{u}_{it})$. In this thesis all the frontier models are estimated using maximum likelihood technique based on the computer software LIMDEP 10.[24]

4.3 Measuring Banking Risk

As illustrated in the literature section in this study, banking risk plays a strong influence on banking performance and increases the possibility of facing serious turmoil by banks maintaining high level of risk. Moreover, as highlighted, also, earlier in this study, one of the main causes of the global financial crisis (2007-2009), was the increasing trend of different banking risks by the time of the crisis. In this study, banking risk will be analysed using descriptive statistics and illustrative figures for the entire period of the study. This allows for investigating the trend of risk in European banking sector before and during the time of the crisis. This banking risk investigation will be extended to compare the level of risk maintained by the banking sectors in the two subsamples of the new and old EU member states and also to shed light on the banking risk performance in the GIIPS countries. The methodology adopted in this study for measuring banking risk is financial ratios. Using financial ratios is a simple and practical method that generates useful measurements, such as the mean, median, and standard deviation, to be analysed using descriptive tables and figures. Moreover, and more importantly in this thesis, such financial ratios can be used as explanatory variables in the one-step efficiency models to investigate the effect of risk on banking cost and profit inefficiencies. In addition, such financial ratios can assist in analysing the effect of risk on banking inefficiency during the crisis time by utilising the interactive variables[25]. Utilising the interaction between risk variables and the world crisis dummy allows for taking the effect of global crisis upon the bank risk-inefficiency relationship.

[24] LIMDEP is econometric software developed by William H. Greene.

[25] An interactive effect exists when the effect of one independent variable on a dependent variable differs based on a third variable's value (Jaccard, 2001).

As discussed in Chapter 2, there are different types of bank risks classified by authors, however, in this thesis we descriptively analyse three types of risks; namely, insolvency risk, credit risk and liquidity risk. The world financial crisis highlighted the importance of these banking risks; hence, they are chosen based on the criterion of serving the objectives of this study and whose data are available for such a large sample of banks operating in the 27 EU states.

Insolvency risk is the risk that a bank might not be able to service its debts and hence becomes insolvent (unable to satisfy its debts). In this sense, it is a long-term survival issue that should encourage the bank to maintain higher level of capital so as to absorb any unexpected shocks or market fluctuations, such as financial or economic crises. Berger and Mester (1997) argue that a bank's insolvency risk depends on its financial capital available to absorb portfolio losses. Also, Rose (1999) argues that one of the popular measures of insolvency risk is the ratio of capital to total assets. Therefore, to measure insolvency risk the well-known financial capital ratio (or equity ratio) is used in this study. The ratio of equity to total assets as a measure of insolvency risk is very common in banking efficiency and risk studies and is used in many of them, such as Allen and Rai (1996), Yildirim and Philippatos (2007), Hasan and Marton (2003), Lozano-Vivas *et al*. (2002) and Fiordelisi *et al*. (2011).

Credit risk can be defined as the probability that the value of some of the bank's assets, particularly loans, would depreciate as some of the bank's borrowers might fail to meet their obligations, such as default on their loans (Rose, 1999). The financial ratio used to measure credit risk in this study is the non-performing loans to gross loans ratio. This ratio as a measure of credit risk is widely used in banking efficiency and risk studies, among those studies are Fries and Taci (2005), Berger and DeYoung (1997), Altunbas *et al*. (2000) and Fiordelisi *et al*. (2011).

Finally, ***liquidity risk*** can be expressed as the risk that a bank is not able to meet its financial obligations, such as deposit withdrawals, net loan demand, and other cash requirements as they come due because it does not have sufficient cash or borrowing capacity at that time (Rose, 1999). An illiquid bank might be forced to borrow emergency cash at a higher interest rate or pay a higher interest rate on issued securities to meet unexpected events, therefore committing more costs and generating less profit. To measure liquidity risk, the ratio of total loans to total assets is used, as the higher the ratio of loans indicates less liquidity position. This measure is used in different studies, such as Yildirim and Philippatos (2007), Havrylchyk (2006), Maudos *et al*. (2002a), Allen and Rai (1996) and Altunbas *et al*. (2000).

4.4 Data Description and Variables

4.4.1 Bank Efficiency and its Determinants

The first objective of this thesis is to measure cost and profit efficiencies and to investigate their relationship with risk and other factors in the 27 banking systems of the European Union member states over the period 2004-2010. The large sample of 27 EU countries is to be further divided into three sub-samples; namely the new EU countries (Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, and Slovenia), the old EU countries (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, and the United Kingdom)[26], and the GIIPS countries (Greece, Ireland, Italy, Portugal, Spain). This sub-sampling allows for comparing banking efficiency and risk between the old and the new EU states as well as highlighting bank efficiency and risk for the GIIPS countries that have faced sovereign debt crises as a reflection of the recent global crisis 2007-2009. The study period of 2004-2010 is of particular importance as it covers the period where 12 of the new EU countries joined the European Union after transitional period in addition to the recent global financial crisis time 2007-2009[27].

The data used to measure bank efficiency and its determinants are collected from balance sheets and income statements of commercial banks provided by "Bankscope" database of BVD-IBCA, and according to Mathieson and Roldos (2001), Bankscope has good

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[26] In this thesis, and following studies, such as Hollo and Nagy (2006), Kosak *et al*. (2009), and Mamatzakis *et al*. (2008), we define the new EU countries as the 12 member states that joined the European Union in 2004 and 2007, while the old EU countries are the 15 states that completed their membership before 2004.
[27] Croatia is excluded from the EU sample as it joined the EU in 2013; the year which is beyond the time period of our study (2004-2010).

advantages. In addition to its broad coverage of banks whose total assets account for 90% of total assets in each country, it allows for logical comparisons between banks and countries as it adjusts all the collected data in one compatible global format. Macroeconomic data, on the other hand, are collected from "Datastream" database developed by Thomson Financial Limited and from the IMF's International Financial Statistics. All data are collected in US dollars rather than euros or local currencies, and therefore data are directly corrected for inflation. According to the Purchasing Power Parity theory (PPP), in general, a country with a lower inflation rate will have a rising currency value that would be reflected by the exchange rate (Mankiw, 2011). Also, Isik and Hassan (2003) argue that the relative version of PPP theory states that the exchange rate between two countries will adjust to reflect changes in the price levels of the two countries. Hence, as data are transformed from the original country currency to the US dollar, then data in this study are corrected for inflation. Using the US dollar to collect data from the 27 countries not only help correcting for inflation but also use a single currency to collect data rather than using different local currencies along with the euro to bring the data in a homogenous format. The focus for measuring efficiency and risk in this thesis is on commercial banks only so as to maintain the homogeneity in such large sample that includes 27 countries and make the comparison between the new and old EU states more logical. We use a sample consisting of unbalanced panel dataset composed of 4250 observations corresponding to 947 commercial banks operating in the 27 EU states, after removing 533 banks whose dependent or independent variables were not available[28] in addition to some outliers, over the period 2004-2010. The sample is restricted to commercial banks whose control and environmental variables are available. Unsurprisingly, the number of commercial banks included in the study sample from the old EU states (745 banks) dominates the number of banks from the new EU states (202 banks). Regarding the GIIPS countries, 202 commercial banks operating in these countries are included in the sample, and Appendix 2a summarises the number of banks and observations for each country over the period 2004-2010. From the sample explained

[28] As an exception, banks whose non-performing loans/gross loans ratios are not available where not removed because removing such banks would significantly shrink and deteriorate our sample, and how to deal with this issue will be explained later in this study.

above, we create a sub-sample of only listed commercial banks for which we have data on the determinants of stock returns, as to be explained in Chapter 7.

Variables Specification and Definition

4.4.1.1 The Input and Output Variables (Control Variables)

A big challenge that is faced by banking efficiency studies is the definition and measurement of inputs and outputs and, unfortunately, there is no consensus on such issue. To specify the input prices and outputs to be used in equations (4.6) and (4.10), two main approaches have been suggested in the literature; namely, the "production approach" and the "intermediation approach"[29]. Under the production approach, banks are considered as mainly producing services for account holders (Berger and Humphrey, 1997), and therefore, physical inputs, such as labour and capital are used to produce bank outputs, such as deposits, loans and other bank liabilities. On the other hand, under the intermediation approach, proposed by Sealey and Lindley (1977), banks are thought of as financial intermediaries that channel funds between savers and investors, and hence deposits, other borrowed funds, capital, and labour are considered as inputs transferred in the production process into outputs, such as loans and other earning assets. While Berger and Humphrey (1997) point out that the production approach is somewhat better for evaluating the efficiency of branches of financial institutions, they argue that the intermediation approach might be more appropriate for evaluating the efficiencies of entire financial institutions. Following modern empirical literature on bank efficiency; such as Hollo and Nagy (2006), Mamatzakis *et al*. (2008) and Altunbas *et al.* (2001), the empirical analysis in this thesis adopts the intermediation approach.

Therefore, according to the intermediation approach, we define input prices as the *price of labour, the price of physical capital*, and *the price of borrowed funds*. Our outputs are *total loans*, *other earning assets*, and *off-balance sheet items*. Even though off-balance sheet items are technically not earning assets, the importance of such items as a source for

[29] There is also the value-added approach proposed by Berger and Humphrey (1992), for more, see Berger and Humphrey (1992).

generating income for banks has been increasing in recent years, and therefore they should be included in cost and profit functions (Jagtiani and Khanthavit, 1996). Among the studies that include off-balance sheet items in the efficiency function are Altunbas *et al*. (2001a), Carbo *et al*. (2002), Havrylchyk (2006) and Altunbas *et al*. (2001b). Finally, as mentioned earlier in the methodology section, the left-hand side of the cost function is the bank total costs, and the left-hand side of the profit function is the bank pre-tax profit, and total costs, pre-tax profit, and the input prices are normalised by the price of borrowed funds. The following table summarises cost and profit functions main variables along with their description:

Table 4.1. Input and Output Variables

Variable	**Symbol**	**Name**	**Description**
Dependent Variables	***TC***	Total Costs	Total interest and non-interest expenses
	$\boldsymbol{\pi}$	Profit	Pre-tax profit
Input Prices	$\boldsymbol{w_1}$	Price of labour	Personnel expenses/total assets*
	$\boldsymbol{w_2}$	Price of physical capital	Other operating expenses(non-interest expenses less personnel expenses)/fixed assets
	$\boldsymbol{w_3}$	Price of borrowed funds	total interest expenses/total funding
Outputs	$\boldsymbol{y_1}$	Total loans	Sum of short- and long-term loans
	$\boldsymbol{y_2}$	Other earning assets	Total earning assets less total loans
	y3	Off-balance sheet items	Total off-balance sheet items
Other Variables	***EQ***	Equity ratio	Equity capital as a proportion of total assets

* We divide personnel expenses by total assets instead because Bankscope does not provide information on the number of employees.

Table 4.2 displays summary statistics for the dependent variables, input prices, outputs and equity ratio that are used in the cost and profit efficiency functions. The table is divided into four samples that represent the entire EU region (EU27), the old EU countries (EU15), the new EU countries (EU12), and the GIIPS countries (EUGIIPS). As can be seen from the table, the mean prices of labour, physical capital, and borrowed funds for the entire EU region are (1.38%), (440.56%), and (2.89%), respectively, while the mean equity ratio stands at 8.90%. The mean prices of labour and borrowed funds are higher for banks in the new EU countries than those in the old EU countries, while the mean prices of physical capital is significantly much higher for banks in the old EU countries. This might be attributed to the idea that commercial banks in the old EU states substitute physical capital for labour while banks in the new EU states prefer to use labour. On the other hand, it appears from the table that over the seven years of our study period commercial banks operating in the old EU states maintain higher insolvency risk on average (equity ratio of 8.59%) than the banks in the new EU states (equity ratio of 10.04%). Regarding the GIIPS countries, the table shows that the prices of labour, physical capital and borrowed funds are lower, on average, than they are in all the old EU countries, while the equity ratio is higher (at 9.32%). Moreover, the mean price of physical capital is lower and the equity ratio is higher for the new EU countries than the GIIPS countries. Finally, it can be noticed that total costs of banks in the new countries are much lower than those in the old countries, though the pre-tax profits are similar in values between the two groups. It can be said here that commercial banks in the old EU countries spend more on technology and fixed assets as well as other expenses as banks might be larger in the old countries. On the other hand, even though total loans in the new EU countries is lower in value than they are in the old countries, banks in the new countries might generate high profits as the markets there might be less competitive allowing banks to impose higher interest rates on loans and also might generate substantial profits from activities other than lending.

Table 4.2. Descriptive Statistics of Dependent Variables, Input Prices and Outputs (2004-2010)

		Dependent Variables		Input Prices			Outputs			Others
Country Sample	**Statistics**	**Total Costs (TC)**	**Pre-tax Profit (π)**	**Price of Labour (w_1) %**	**Price of Physical Capital (w_2) %**	**Price of Borrowed Funds (w_3) %**	**Total Loans (y_1)**	**Other Earning Assets (y_2)**	**Off-balance Sheet (y_3)**	**Equity Ratio (EQ) %**
EU27	Obs	4250	4250	4250	4250	4250	4250	4250	4250	4250
	Mean	1555.352	25957.64	1.38378	440.5642	2.88544	19314.13	21900.85	9810.643	8.904146
	Std.Dev	7069.024	1453.95	1.28056	1191.002	2.64469	82502.18	127599.3	66043.38	7.01275
	Min	29.411	-309296	0.004	2.193	0.260	0.623	0.79	0.996	0.100
	Max	808014	3564748	5.171	670.212	6.731	1113372	2449260	3061809	75.2
EU15	Obs	3322	3322	3322	3322	3322	3322	3322	3322	3322
	Mean	1921.987	25989.58	1.37731	512.1451	2.80755	23918.32	27588.56	12275.13	8.585647
	Std.Dev	7954.552	1640.722	1.36373	1329.414	2.83927	92762.19	143805.6	74508.51	7.22214
	Min	29.411	-309296	0.004	4.224	0.260	2.211	1.300	1.025	0.110
	Max	808014	3564748	5.171	670.212	6.731	1113372	2449260	3061809	75.2
EU12	Obs	928	928	928	928	928	928	928	928	928
	Mean	242.8944	25843.28	1.40693	184.323	3.16425	2832.33	1540.301	988.3998	10.04429
	Std.Dev	397.1612	169.7118	0.92358	293.489	1.75482	4888.007	3254.277	2072.892	6.073602
	Min	31.002	-116794	0.02	2.193	0.943	0.623	0.79	0.996	0.100
	Max	13326	304222	4.23	390.200	5.992	242171	224510	26691	68.9
EUGIIPS	Obs	797	797	797	797	797	797	797	797	797
	Mean	1510.04	26014.99	1.2782	465.7065	2.34098	23886.28	11143.67	8042.482	9.321405
	Std.Dev	5480.222	1844.107	0.91238	1571.826	1.35118	77956.47	39489.51	30592.13	7.968401
	Min	85.412	-309296	0.004	3.551	0.347	1.000	0.88	1.000	0.200
	Max	274335	3151240	4.23	592.110	4.211	994527	1051720	1944430	73.3

***Note:* All values are in millions of US$, except where indicated.**

4.4.1.2 The Environmental Variables (Efficiency Correlates)

Even though the integration between the 27 EU states, particularly between the new and old EU states, has strengthened during the last decade as a result of economic convergence and harmonisation introduced by the "Acquis Communautaire", there still exist differences in the macroeconomic and regulatory environment (Hollo and Nagy, 2006). Without taking such differences, that are out of the control of bank management, into account, differences in cost and profit efficiencies among banks and across countries would be fully attributed to the bank managerial decisions, which might not be the case.

So, it is crucial to investigate different bank efficiency correlates that might help in explaining differences in efficiency (or inefficiency) between banks and across countries, which might provide important implications for public policy, research and bank management (Berger and Mester, 1997). These variables are not generally controlled by bank management, or at least are partially exogenous. As explained earlier in equation (4.8), the inefficiency component will be regressed in the one-step model, according to Battese and Coelli (1995), against different efficiency correlates (independent variables). In this thesis, we divide the explanatory (independent) variables into two groups, *banking risk* variables and *other explanatory* variables. While the first group includes the three risk variables discussed above and their interaction with the crisis variable, the latter group include different bank specific, industry, and macroeconomic variables. We define the variables in each group as follows:

1. Banking Risk Variables

- **Equity Ratio (Insolvency Risk)**

This ratio measures the financial insolvency risk of a bank and is calculated as the ratio of equity capital to total assets. Berger and Mester (1997) argue that insolvency risk influences costs and profits of banks through the higher risk premium that has to be paid by banks to borrow and through the costs involved with risk management activities, in which case equity ratio should have a negative effect on bank cost and profit inefficiencies. However, the direction of the effect of this variable might be the reverse as raising capital is more expensive than debt or if the moral hazard hypothesis, where banks with low solvency position would undertake risky business to compensate, holds. Therefore, we do not have a prior expectation for the influence of equity ratio on cost and profit inefficiencies. A negative correlation between capital and inefficiency is confirmed by Fries and Taci (2005), Yildirim and Philippatos (2007), and Grigorian and Manole (2002). On the other hand, a positive correlation between bank inefficiency and equity ratio is observed by Altunbas *et al*. (2007), Allen and Rai (1996) and Hasan and Marton (2003), suggesting that risk-averse banks are associated with lower efficiency.

- **Equity Ratio * Crisis**

As explained in the literature earlier in this thesis, the level of risk maintained by banks played a key role in the global financial crisis 2007-2009. Part of that risk was enhanced by high level of financial leverage (low level of equity ratio) maintained by banks by the time of the world crisis. To shed light on the nature of the correlation between bank inefficiency and insolvency risk during the global crisis time and how the crisis affected such a relationship, we create an interactive variable between the equity ratio and the dummy variable of the world financial crisis 2007-2009 (the crisis dummy to be explained later). The expected sign of this variable is negative regarding both cost and profit inefficiency, suggesting that commercial banks with higher capital ratio are more efficient as they are more capable of surviving the negative effects of the crisis than less capitalised banks.

- **Total Loans/Total Assets (Liquidity Risk)**

This ratio can be considered as a liquidity ratio with higher total net loans/total assets ratio meaning less liquidity position for a bank as loans are among the most illiquid assets. This ratio is of particular interest as an illiquid bank might face an emergency borrowing at higher interest rate to meet its obligations, and even worse, an illiquid bank might face bank runs[30] forcing it to fail even though it might be solvent. In this sense, this liquidity ratio is expected to have a positive effect on bank cost inefficiency; however, an adverse effect is confirmed by studies, such as Yildirim and Philippatos (2007) and Allen and Rai (1996). Regarding profit inefficiency, total loans/total assets ratio is expected to influence profit inefficiency negatively as a higher risky position is correlated with higher profits, and also the return on loans is higher than the return on liquid assets, such as government securities. Yildirim and Philippatos (2007) and Maudos *et al*. (2002a), find no significant relationship between profit inefficiency and loans-to-assets ratio.

[30] Bank run is the situation when a large number of a bank's clients withdraw their money (or deposits) because of their concerns about the solvency issue of the banks, which might force the bank to go bankrupt as a result.

- **Total Loans/Total Assets * Crisis**

It is interesting to shed light on the effect of the world crisis 2007-2009 on the relationship between liquidity risk and bank inefficiency. In other words, a question of interest is to what extent the liquidity risk affects bank cost and profit inefficiencies during the crisis time. To answer this question, an interactive variable is created between liquidity risk and the dummy variable of the world financial crisis 2007-2009, as in the case of equity ratio and the crisis interactive variable. This variable is expected to have a positive effect on cost and profit inefficiencies as banks with higher liquidity might have decreased the costs of emergency borrowing and the costs of losses associated with default loans in the credit crunch state during the crisis time.

- **Non-Performing Loans/Gross Loans (Credit Risk)**

One good measure of bank credit risk is the ratio of non-performing loans to total loans that reflects potential losses for a bank. The International Monetary Fund defines a non-performing loan as follows: “A loan is non-performing when payments of interest and principal are past due by 90 days or more, or at least 90 days of interest payments have been capitalized, refinanced or delayed by agreement, or payments are less than 90 days overdue, but there are other good reasons to doubt that payments will be made in full.”[31] The higher the ratio of the non-performing loans to total loans is, the more risky a bank is, which in turn might affect the bank inefficiency. As the percentage of non-performing loans increases, the bank costs related to monitoring, working out, or selling off bad loans increase, and therefore, this variable is expected to positively affect cost inefficiency. Berger and DeYoung (1997), Fries and Taci (2005), and Altunbas *et al*. (2000) find non-performing loans to total loans ratio to be positively correlated with bank cost inefficiency. Similarly, this variable is expected to be positively associated with bank profit inefficiency as it would increase costs and expenses related to the loan-loss provision[32] in the income statement, which in turn reduces a bank’s net income (profits). It is important to refer here that regarding this variable and due to missing data, we will

[31] In Bloem and Freeman (2005), p. 2.
[32] Loan-loss provision is an expense set aside to account for possible losses on loan defaults.

run a separate regression model and include only the observations for which data of this variable are available.

- **Non-Performing Loans/Gross Loans * Crisis**

As explained in the literature above on the causes of the world crisis, the credit risk was increased at financial institutions due to different reasons. To see what role the credit risk played in terms of bank cost and profit inefficiencies during the crisis time, we create interactive variables between the ratio of non-performing loans to total loans and the dummy variable of the world crisis 2007-2009. For the reasons mentioned above, we expect that bank cost and profit inefficiencies are positively correlated with the level of non-performing loans to total loans during the crisis time.

2- Other Explanatory Variables

- **Size**

Bank size is measured by taking the logarithm of total bank assets measured in millions of US dollars to account for a possible non-linear relationship between bank inefficiency and size. Bank size is expected to affect negatively both cost and profit inefficiencies, meaning that larger banks are expected to be more cost and profit efficient probably due to, as Yildirim and Philippatos (2007: 138) refer, “the relaxation of asset restrictions in the banking system that [allows] banks to grow and venture into different banking business practices, and to accrue some economies of scale and scope.” The expected positive relationship between size and efficiency could also be attributed to the higher ability of large banks to attract and retain better bank managers, as discussed by De Young and Nolle (1998). Although we expect a positive relationship between bank size and efficiency, this relationship might be negative. Isik and Hassan (2002) argue that the overhead costs of small banks might be low because they often operate few branches compared to larger banks, so they may possess operational advantage which might results in higher efficiency. Also, larger banks might issue loans to a larger number of people and in small amount, which in turn might increase the costs of servicing and monitoring leading to lower efficiency. Size has been used enormously in bank efficiency studies and has been found to have a negative effect on bank inefficiency in studies, such as Hasan and Marton (2003), Yildirim and Philippatos (2007), and Matousek and Taci (2004), while the reverse is found by Bonin *et al*. (2005) and Allen and Rai (1996).

- **Return on Average Assets (ROAA)**

ROAA is a proxy used to assess the profitability of a bank's assets and is calculated by dividing the net income by the average total assets. ROAA is a bank performance measure and is expected to be negatively correlated with bank cost and profit inefficiencies. Chan and Abd Karim (2010) in their study on bank cost and profit efficiency in developing countries find a negative relationship between bank profit inefficiency and the return on assets meaning better utilisation of assets enhances bank profit efficiency. Carbo *et al*. (2002) and Lensik *et al*. (2008) find this variable to have a negative effect on bank cost inefficiency, while Matousek and Taci (2004) find it to positively affect bank inefficiency.

- **Intermediation Ratio**

Intermediation ratio represents the overall depth of bank intermediation activity and reflects the ability of banks to convert deposits into loans, and is calculated by dividing total loans by total deposits. This variable is expected to negatively influence bank inefficiency because higher intermediation ratio means less deposits are required to produce loans, which in turn means lower production costs and hence higher profits. Kosak *et al*. (2009), Fries and Taci (2005), and Dietsch and Lozano-Vivas (2000) find the expected negative relationship between intermediation ratio and bank cost inefficiency.

- **Market Concentration**

Market concentration is calculated as the sum of total assets of the five largest banks divided by the total assets of the entire banking system. There are two main hypotheses that explain the relationship between market concentration and efficiency. ***Structure-Conduct-Performance (SCP)*** hypothesis assumes that a higher bank concentration allows a higher degree of cooperation between them. These banks might set higher prices and consequently gain substantial profits [see Heffernan (1996) and Molyneux *et al*., (1996)].

On the other hand, the ***Efficiency-Structure (ES)*** hypothesis suggests that a bank which operates more efficiently than its competitors gains higher profits resulting from low operational costs and holds an important share of the market [see Demsetz (1973) and Berger (1995)].

Banks operating in a more concentrated market, where the level of competition might be lower, are expected to have greater market power and therefore charge higher prices and generate more profits. In this sense, we expect that higher concentration ratio is correlated negatively with bank profit inefficiency, as it is confirmed by Maudos *et al*. (2002a). In terms of cost inefficiency, the concentration ratio might affect negatively cost inefficiency if concentration is a consequence of a better management or implementing the production process more efficiently (Demsetz, 1973). On the other hand, if concentration is a result of market power, then that would induce banks to spend more on staff and other personnel expenses (Leibenstein, 1966), or banks would feel less pressure to control their costs, and therefore concentration ratio would have a positive influence upon cost inefficiency. Therefore, we do not have specific sign for the relationship between bank cost inefficiency and market concentration ratio, which could be positive or negative. Dietsch and Lozano-Vivas (2000), Fries and Taci (2005), and Kosak *et al*. (2009) find positive linkage between cost inefficiency and market concentration, while Maudos *et al*. (2002a) find this linkage to be negative.

- **Inflation Rate**

A macroeconomic variable that might have a potential effect on bank cost and profit inefficiency which is to be investigated in this study, is inflation rate. Grigorian and Manole (2002) argue that inflation might have a positive correlation with bank inefficiency as excessive branch networks are often associated with high inflationary environment. Hanson and Rocha (1986) argue that inflation increases bank costs as large number of transactions might be associated with higher labour costs causing higher ratio of bank branches per capita. In addition, an increase in inflation rate might increase interest rates which might lead to higher costs faced by banks. Revell (1979) argues that the impact of inflation on bank costs and profits depends on the rate at which operating expenses increased as opposed to the inflation rate. Athanasoglou *et al*. (2006) suggest that the influence of inflation on bank profits depends on how capable a bank is to forecast inflation so as to bank managements handle their expenses and their interest rates in order to generate profits. In this sense, if commercial banks have the ability to successfully forecast changes in inflation rate, then that would positively affect bank profitability. In our study where our sample contain banks operate in 27 countries, we do not have the expected signs, either in terms of the effect of inflation on bank cost inefficiency or on bank profit inefficiency. However, Weill (2003a) and Grigorian and Manole (2002) find no significant relationship between inflation and bank inefficiency, while Tomova (2005) finds a positive impact of inflation on bank technical efficiency.

- **Nominal Interest Rate**

We use the long-term government bond yield provided by "Datastream" database to represent this variable. The change in interest rate might affect bank costs and profits in different directions. As Rose (1999) argues, an increase in market interest rate would raise bank profits if a bank maintains an excess of flexible-rate assets over flexible-rate liabilities, and would increase bank costs and decrease bank profits in the reverse situation. Unless banks are hedged against interest rate movements, they might face high losses and costs, and hence lower profits. However, higher interest rates might increase bank interest costs and increase inefficiency in risk management and credit evaluation through greater ambiguity and risk. Therefore, we would expect a positive relationship between nominal interest rate and bank cost inefficiency, as found by Fries and Taci (2005), but we do not have an expected sign in the case of profit inefficiency.

- **World Financial Crisis (2007-2009[33])**

As financial markets have become globally more integrated due to the world economic globalisation, it was not possible for the European Union banking system to isolate itself against a possible financial and banking contagion of the recent financial crisis that originated in the United States. To investigate the effect of the world financial crisis on the inefficiency of the commercial banking system in the EU, we construct a dummy

[33] In this study we focus on potential contagion of the global financial crisis 2007-2009 that originated in the US, therefore we consider the years from 2007 to 2009 as the period of the crisis following studies, such as Eubanks (2010b) and Mishkin and Eakins (2012).

variable which takes the value of 1 for the years 2007-2009, and 0 otherwise. We would expect that the world crisis affects both bank cost and profit inefficiency positively, meaning that it might have reduced banks' profits and increased banks' costs as a result of the economic turmoil and recession the crisis led to in the EU region. Banks might have faced higher costs related to; first, expensive borrowing in a credit crunch environment, second, raising capital (deleveraging), and third, monitoring and evaluating the creditworthiness of clients, leading to more expenses associated with risk management at the crisis time. On the other hand, banks' profits are also expected to be affected negatively by the crisis because of; first, lower lending activity followed by deposits withdrawal and low liquidity, second, the losses associated with the loan defaults and other assets over the crisis period, and third the increase in bank costs, as just explained above, that leads to lower profits.

- **Country Dummy**

In this study we tend to make a comparison between bank cost and profit efficiencies in the old and new EU member states to see in which area banks operate more efficiently. We investigate such difference by including a dummy variable that takes the value of 1 if a bank operates in the old EU states and 0 if a bank operates in the new EU states. As banks in the new EU states had to meet different criteria related to economic and political reforms and financial requirements, we would expect that cost and profit efficiency of commercial banks in such countries have continued to increase, at least in the early years of the time period we consider in this thesis. However, we still believe that commercial banks in the new EU states could not fully catch up or exceed the cost efficiency level of banks in the old EU states due to the higher level of competition and technological development and the better management techniques the old countries maintain in their banking and financial markets. In this sense, we would expect the country effect variable to have a negative effect on bank cost inefficiency, while we have no expectation with regard to profit inefficiency as banks in the new EU countries might benefit from less competitive environment to make some monopolistic profits and hence appear more profit efficient.

- **Country Dummy * Crisis**

To investigate whether bank cost and profit inefficiencies were affected more by the world crisis and in what direction in the old or in the new EU countries; we create an interactive variable between the country effect dummy variable and the world crisis dummy variable. Because of the more integrated financial markets and institutions between the old EU states and the US, and because financial institutions were more involved in investing in the US mortgage toxic securities and other financial instrument in the US than those in the new EU countries, we would expect this variable to have a positive influence on both bank cost and profit inefficiency. This means that cost and profit efficiencies of commercial banks in the old EU member states might have been negatively more affected by the crisis than their counterparts in the new EU states.

- **GIIPS-Dummy**

To investigate whether banks operating in the GIIPS countries differs from banks operating in the other EU countries in terms of cost and profit efficiencies, we create a dummy variable that takes the value of 1 for banks operating in these five countries, or 0 otherwise. As the sovereign debt crises started after the occurrence of the world financial crisis, and since our time period covers from 2004-2010, we do not really have expectations as to the effect of such a dummy variable on bank cost and profit inefficiency.

- **GIIPS-Dummy * Crisis**

To find out whether the world crisis affected cost and profit efficiencies of banks that operate in the GIIPS countries more or less than banks operating in the rest of the EU states, we construct an interactive variable between GIIPS-Dummy variable and the world crisis dummy variable. Again, we do not have expectations as to the effect of such a dummy variable on bank cost and profit inefficiency.

Appendix 2b summarises the explanatory variables stated above along with their description, and the expected sign of their effects on bank cost and profit inefficiency.

Furthermore, Appendix 2c provides descriptive statistics for all the aforementioned environmental variables.

4.5 Summary and Conclusion

This chapter summarises the methodological approaches that are used to estimate cost and profit efficiencies in the European Union banking system over the period from 2004 until 2010. We employ the stochastic frontier analysis (SFA) and the Battese and Coelli (1995) model to measure bank cost and profit efficiencies and investigate their determinants. This chapter outlines the specifications of translog cost and profit frontier functions for panel data based on the Battese and Coelli (1995) one-step model. It also highlights the financial ratios adopted to measure insolvency, credit and liquidity risks at the EU commercial banks. Furthermore, this chapter describes the dataset and variables used for the empirical analysis which include the input and output variables as well as the determinants of bank efficiency (efficiency correlates). We use a sample consisting of an unbalanced panel dataset composed of 4250 observations corresponding to 947 commercial banks operating in the EU countries over the period 2004-2010. The intermediation approach is followed to specify the input and output variables for the efficiency functions. The efficiency correlates, in turn, are divided into two groups; the first group represents bank risk variables, while the second group represents the explanatory variables. The definitions, descriptions and expected signs of these variables are also discussed in this chapter.

Chapter 5

Empirical Analysis of Efficiency in the European Union Banking Sector

5.1 Introduction

This chapter analyses the efficiency of the European Union banking system for the years from 2004 to 2010. Using the stochastic frontier approach based on the Battese and Coelli (1995) model, cost and profit efficiencies scores are generated for four EU samples. This chapter aims further to investigate and compare cost and profit efficiency levels based on a common frontier, that pools together all the EU commercial banks used in this study, and based on separate efficiency frontiers. The evolution and dispersion of the EU bank efficiencies over time are investigated along with the efficiency gap between the old and the new EU members. Also, this chapter indicates in what way the level of bank efficiencies during the world financial crisis 2007-2009 is affected. Therefore, this chapter addresses the first research question in this thesis.

The rest of this chapter is organised as follows: Section 5.2 reports the maximum likelihood parameter estimates for the stochastic translog cost and profit functions. Section 5.3 introduces the empirical results of cost and profit efficiency mean estimates for the four sub-samples based on a comparison between the common frontier and the separate frontiers. In addition, the mean efficiency scores for all the 27 EU countries and the efficiency gap between the old and the new EU states as well as efficiency levels by size groups are analysed based on the common frontier in Section 5.3. Section 5.4 discusses the evolution of bank cost and profit efficiencies for the individual EU countries and the four sub-samples in addition to the evolution of efficiency gap between the old and the new EU member states over the period 2004-2010 based on the common frontier. Section 5.5 investigates the dispersion (heterogeneity) of bank cost and profit efficiencies over time and within the four groups of the EU member states. In Section 5.6 we examine the influence of the global financial crisis on cost and profit efficiency levels for all the four sub-samples by comparing the mean efficiency scores in the crisis, the non-crisis, and in the entire time period under study. Section 5.7 provides summary and conclusion.

5.2 Efficiency Frontier Estimates

5.2.1 Cost Frontier Estimates

The stochastic frontier models are used to estimate cost efficiency of 947 commercial banks operating in the 27 European Union member states over the period 2004-2010. Table 5.1 summarises the maximum likelihood estimates of parameters of the translog cost function based on the SFA and the Battese and Coelli (1995) truncated normal distribution.

Table 5.1 Maximum Likelihood Estimates for Cost Function Models

Variables	Parameters	Common Frontier	Separate Frontiers		
		Model 1 (EU27)	Model 2 (EU15)	Model 3 (EU12)	Model 4 (EUGIIPS)
Constant	β_0	8.116*** (0.0079)	8.1157*** (0.0088)	8.2465*** (0.0147)	8.17424*** (0.0149)
ln(W$_1$/W$_3$)	χ_1	0.4448*** (0.0026)	0.4454*** (0.0029)	0.4816*** (0.0111)	0.4783*** (0.0067)
ln(W$_2$/W$_3$)	χ_2	0.0482*** (0.0016)	0.0498*** (0.0018)	0.0539*** (0.0077)	0.0259*** (0.0052)
0.5ln(W$_1$/W$_3$)ln(W$_1$/W$_3$)	δ_{11}	0.1404*** (0.0024)	0.1435*** (0.0026)	0.1916*** (0.0142)	0.1341*** (0.0055)
0.5ln(W$_2$/W$_3$)ln(W$_2$/W$_3$)	δ_{22}	0.0050*** (0.0012)	0.0071*** (0.0013)	-0.0010 (0.0065)	0.0027 (0.0040)
ln(W$_1$/W$_3$)ln(W$_2$/W$_3$)	δ_{12}	0.0086*** (0.0014)	0.0054*** (0.0016)	0.0295*** (0.0055)	0.0058 (0.0041)
lnY$_1$	β_1	0.6917*** (0.0039)	0.6927*** (0.0043)	0.6495*** (0.0123)	0.6775*** (0.0083)
lnY$_2$	β_2	0.2642*** (0.0042)	0.2715*** (0.0048)	0.3101*** (0.0108)	0.2882*** (0.0095)
lnY$_3$	β_3	0.0064** (0.0027)	0.0029 (0.0029)	0.0199** (0.0096)	0.0079 (0.0064)
0.5lnY$_1$lnY$_1$	φ_{11}	0.1282*** (0.0012)	0.1257*** (0.0014)	0.1631*** (0.0104)	0.1189*** (0.0036)
0.5lnY$_2$lnY$_2$	φ_{22}	0.0769*** (0.0013)	0.0749*** (0.0014)	0.1062*** (0.0055)	0.0905*** (0.0056)
0.5lnY$_3$lnY$_3$	φ_{33}	0.0010 (0.0016)	0.0004 (0.0017)	0.0016 (0.0070)	0.0097*** (0.0035)
lnY$_1$lnY$_2$	φ_{12}	-0.0974*** (0.0012)	-0.0979*** (0.0014)	-0.1216*** (0.0055)	-0.0970*** (0.0045)
lnY$_1$lnY$_3$	φ_{13}	-0.0074*** (0.0012)	-0.0064*** (0.0012)	-0.0205*** (0.0069)	-0.0101** (0.0042)
lnY$_2$lnY$_3$	φ_{23}	0.0052*** (0.0005)	0.0059*** (0.0006)	0.0139*** (0.0053)	-0.00005 (0.0032)
lnY$_1$ln(W$_1$/W$_3$)	ψ_{11}	0.0111*** (0.0016)	0.0101*** (0.0016)	0.0169** (0.0086)	-0.0052 (0.0049)
lnY$_2$ln(W$_1$/W$_3$)	ψ_{21}	-0.0114*** (0.0014)	-0.0081*** (0.0016)	-0.0087 (0.0075)	0.0051 (0.0055)
lnY$_3$ln(W$_1$/W$_3$)	ψ_{31}	0.0002 (0.0015)	-0.0002 (0.0016)	-0.0024 (0.0075)	-0.0077* (0.0040)
lnY$_1$ln(W$_2$/W$_3$)	ψ_{12}	0.0062* (0.0122)	0.0065*** (0.0025)	0.0225 (0.0074)	0.0160* (0.0154)
lnY$_2$ln(W$_2$/W$_3$)	ψ_{22}	0.0053* (0.0027)	0.0047** (0.0045)	0.0020 (0.0134)	0.0051 (0.0118)
lnY$_3$ln(W$_2$/W$_3$)	ψ_{32}	0.0014 (0.0009)	0.0029*** (0.0010)	-0.0018 (0.0043)	0.0029 (0.0029)
lnEQ	τ_1	-0.0602*** (0.0054)	-0.0671*** (0.0060)	-0.0593*** (0.0193)	-0.0813*** (0.0129)
0.5lnEQlnEQ	τ_{11}	-0.0146*** (0.0040)	-0.0231** (0.0090)	-0.0443*** (0.0120)	0.0028 (0.0209)
lnEQln(W$_1$/W$_3$)	ξ_{11}	0.0234*** (0.0030)	0.0234*** (0.0033)	0.0388*** (0.0132)	0.0268** (0.0109)
lnEQln(W$_2$/W$_3$)	ξ_{12}	0.0059*** (0.0020)	0.0066*** (0.0023)	-0.0259** (0.0105)	0.0021 (0.0066)
lnEQlnY$_1$	ω_{11}	0.0293*** (0.0030)	0.0232*** (0.0035)	0.0264** (0.0129)	0.0315*** (0.0116)
lnEQlnY$_2$	ω_{12}	-0.0150*** (0.0022)	-0.0109*** (0.0033)	-0.0083 (0.0091)	-0.0024 (0.0099)
lnEQlnY$_3$	ω_{13}	-0.0052** (0.0022)	-0.0036 (0.0026)	-0.0090 (0.0113)	-0.0059 (0.0081)
Sigma	σ	0.872	0.383	0.385	0.204
Eta	η	0.0202*** (0.0149)	0.0113*** (0.0015)	0.0151*** (0.0055)	0.0643*** (0.0136)
Lambda	λ	8.409*** (0.0286)	5.333*** (0.0468)	5.378*** (0.0358)	2.911*** (0.0789)
Gamma	γ	0.986	0.966	0.966	0.894
Log likelihood function	***LogL***	2557.749	2098.326	1340.464	697.387

***, ** and * indicate 1%, 5% and 10% significance levels, respectively, and asymptotic standard errors in parentheses. Ws and Ys represent input prices and outputs respectively, EQ is equity ratio, σ is standard deviation, $\gamma = \sigma_u^2/(\sigma_v^2 + \sigma_u^2)$, $\lambda = \frac{\sigma_u}{\sigma_v}$, *Log is* Log Likelihood. Estimates based on Battese and Coelli (1995) model using Limdep10 software.

Model 1 contains parameter estimates of the translog cost function using a common frontier for all the commercial banks from all the 27 EU member states included in the study sample. In Model 2, Model 3, and Model 4 separate cost frontiers are created for EU country groups; (EU15), (EU12) and (EUGIIPS), respectively. Model 1 is considered as the main model in this study as it incorporates all banks from all EU countries together allowing for a logical comparison to be implemented between banks within these countries.

Table 5.1 shows that the parameters of all the normalised input prices and the outputs are, in general, positive and highly significantly different from zero at level 1%, meaning that the cost function is non-decreasing in input prices (Ws) and in the outputs (Ys). In the main model (Model 1) the coefficient estimate of the total loans (y_1) suggests that, on average, an increase by 1% in the total loans will lead to increase by 0.69% in the total costs. Correspondingly, the cost elasticity with regard to other earning assets (y_2) is 0.26, meaning that a 1% increase in other earning assets will increase costs by 0.26%. Moreover, in spite of the positive and significant sign (at 5%) obtained for the off-balance sheet items (y_3) coefficient (0.0064), the magnitude of this coefficient is very small compared to the estimated coefficients of (y_1) and (y_2). This means that the off-balance sheet items have, on average, little effect on total costs of commercial banks in the EU states according to Model 1, while this coefficient has no significant effect on costs in the case of Model 2 and Model 4. With regard to the input prices, the table shows that the estimated coefficient of the price of labour (w_1) is positive and highly significant and suggests that a 1% increase in the price of labour will raise total costs by about 0.44%, according to Model 1. The magnitude of the coefficient (0.05) of the price of physical capital (w_2) is smaller than that of the price of labour, meaning that bank total costs are more sensitive to the price of labour than they are to the price of physical capital. Furthermore, the coefficients of the equity ratio (risk preference) are negative and highly significant (at 1%) in all the four models, meaning that an increase in the amount of equity relative to the total assets will decrease total costs. However, the magnitude of the equity coefficient is small and ranges from 0.06 to 0.08 in all models. Also, according to Model 1, it can be derived that the sum of the three output elasticities is slightly less than unity

(0.962) meaning that banks in the EU operate at increasing return to scale (or scale economies).

Gamma parameter, $\gamma = \sigma_u^2/(\sigma_v^2 + \sigma_u^2)$[34], indicates the proportion of the variance in disturbance due to inefficiency and takes a value between 0 and 1, and it ranges from about 0.99 to 0.89 in the table. According to Model 1 in the table, the value of $\boldsymbol{\gamma}$ is about 0.986 meaning that the variation of inefficiency is more important than other stochastic variations in the cost frontier model. In other words, this value suggests that the majority of residual variation is due to the inefficiency effect and that the random error is about 1%. Lambda, $\lambda = \sigma_u/\sigma_v$ refers to the ratio of inefficiency standard deviation to the standard deviation of other stochastic factors and it is positive and significant in all models. Eta is positive and highly significant (time-varying inefficiency) for all the models meaning that inefficiency tends to decrease with time for all the models[35]. Finally, the values in the last row are the log likelihood functions for the four models based on the common frontier and separate frontiers.

5.2.2 Profit Frontier Estimates

Translog profit function based on the SFA and the Battese and Coelli (1995) truncated model is estimated using the maximum likelihood technique. Table 5.2 below summarises the estimates of the translog profit function using this technique.

[34] For more on Gamma and Lambda, refer to Battese and Corra (1977).
[35] Refer to section 4.2.2 in the methodology chapter.

Table 5.2 Maximum Likelihood Estimates for Profit Function Models

Variables	Parameters	Common Frontier	Separate Frontiers		
		Model 1 (EU27)	Model 2 (EU15)	Model 3 (EU12)	Model 4 (EUGIIPS)
Constant	β_0	14.4699*** (0.0117)	14.4863*** (0.0148)	14.4997*** (0.0385)	14.372*** (0.0448)
$\ln(W_1/W_3)$	χ_1	0.5723*** (0.0060)	0.5694*** (0.0078)	0.6218*** (0.0200)	0.4688*** (0.0189)
$\ln(W_2/W_3)$	χ_2	0.1466*** (0.0037)	0.1362*** (0.0048)	0.1368*** (0.0162)	0.0611*** (0.0165)
$0.5\ln(W_1/W_3)\ln(W_1/W_3)$	δ_{11}	0.0875*** (0.0051)	0.0771*** (0.0063)	0.1144*** (0.0317)	0.0946*** (0.0227)
$0.5\ln(W_2/W_3)\ln(W_2/W_3)$	δ_{22}	0.0145*** (0.00252)	0.0173*** (0.0030)	-0.0121 (0.0148)	-0.0136 (0.0118)
$\ln(W_1/W_3)\ln(W_2/W_3)$	δ_{12}	0.0001 (0.0026)	-0.0017 (0.0031)	0.0198 (0.01325)	-0.0053 (0.0112)
$\ln Y_1$	β_1	0.5760*** (0.0065)	0.4768*** (0.0080)	0.4595*** (0.0230)	0.3340 (0.0233)
$\ln Y_2$	β_2	0.3817*** (0.0070)	0.4933*** (0.0088)	0.4446*** (0.0225)	0.5637*** (0.0277)
$\ln Y_3$	β_3	0.1085* (0.0050)	0.1105* (0.0067)	0.1078* (0.0195)	0.1465** (0.0229)
$0.5\ln Y_1\ln Y_1$	φ_{11}	-0.0032 (0.0035)	-0.0087** (0.0041)	0.0172 (0.0153)	0.0049 (0.0130)
$0.5\ln Y_2\ln Y_2$	φ_{22}	0.0548*** (0.0042)	0.0573*** (0.0048)	0.0481*** (0.0145)	0.0684*** (0.0175)
$0.5\ln Y_3\ln Y_3$	φ_{33}	-0.0102*** (0.0035)	-0.0069 (0.0051)	-0.0270*** (0.0095)	0.0108 (0.0143)
$\ln Y_1\ln Y_2$	φ_{12}	-0.0417*** (0.0022)	-0.0439*** (0.0041)	-0.0473*** (0.0107)	-0.0479*** (0.0138)
$\ln Y_1\ln Y_3$	φ_{13}	0.0101*** (0.0029)	0.0079** (0.0037)	0.0133 (0.0111)	0.0046 (0.0101)
$\ln Y_2\ln Y_3$	φ_{23}	0.000003 (0.0027)	0.0036 (0.0034)	0.0017 (0.0092)	-0.0082 (0.0138)
$\ln Y_1\ln(W_1/W_3)$	ψ_{11}	-0.0185*** (0.0033)	-0.0196*** (0.0037)	0.0186 (0.0185)	-0.0129 (0.0195)
$\ln Y_2\ln(W_1/W_3)$	ψ_{21}	0.0060* (0.0034)	0.0033 (0.0041)	-0.0202 (0.0139)	-0.0106 (0.0147)
$\ln Y_3\ln(W_1/W_3)$	ψ_{31}	0.0075** (0.0031)	0.0076** (0.0037)	-0.0032 (0.0166)	0.0064 (0.0119)
$\ln Y_1\ln(W_2/W_3)$	ψ_{12}	-0.0052** (0.0022)	-0.0075*** (0.0025)	0.0135 (0.0094)	-0.0270* (0.0149)
$\ln Y_2\ln(W_2/W_3)$	ψ_{22}	0.0046* (0.0026)	0.0059** (0.0030)	-0.0010 (0.0125)	0.0041 (0.0121)
$\ln Y_3\ln(W_2/W_3)$	ψ_{32}	0.0050** (0.0022)	0.0067** (0.0028)	-0.0077 (0.0088)	0.0245** (0.0102)
lnEQ	τ_1	-0.0585*** (0.0097)	-0.0533*** (0.0145)	-0.1896*** (0.0284)	-0.0870** (0.0412)
0.5lnEQlnEQ	τ_{11}	-0.0301*** (0.0071)	0.0146 (0.0161)	-0.0808** (0.0360)	0.0372 (0.0612)
$\ln EQ\ln(W_1/W_3)$	ξ_{11}	0.0446*** (0.0063)	0.0613*** (0.0092)	-0.1069*** (0.0316)	0.0610 (0.0395)
$\ln EQ\ln(W_2/W_3)$	ξ_{12}	-0.0085 (0.0053)	-0.0127* (0.0066)	-0.0046 (0.0283)	-0.0137 (0.0325)
$\ln EQ\ln Y_1$	ω_{11}	-0.0069 (0.0058)	-0.0116 (0.0078)	-0.0475** (0.0200)	0.0310 (0.0227)
$\ln EQ\ln Y_2$	ω_{12}	0.0214*** (0.0051)	0.0384*** (0.0079)	0.0014 (0.0164)	0.0069 (0.0224)
$\ln EQ\ln Y_3$	ω_{13}	-0.0062 (0.0043)	0.0064 (0.0062)	0.0151 (0.0168)	0.0152 (0.0240)
Sigma	σ	0.504	0.427	0.440	0.352
Eta	η	0.0085*** (0.0009)	0.0036** (0.0024)	0.1689** (0.2151)	0.2225** (0.3918)
Lambda	λ	2.418*** (0.0089)	2.033*** (0.0181)	2.081*** (1.7843)	0.735*** (2.3085)
Gamma	γ	0.854	0.805	0.812	0.751
Log likelihood function	***LogL***	540.767	335.079	111.5624	124.8984

***,** and * indicate 1%, 5% and 10% significance levels, respectively, and asymptotic standard errors in parentheses. *W*s and *Y*s represent input prices and outputs respectively, EQ is equity ratio, σ is standard deviation, $\gamma = \sigma_u^2/(\sigma_v^2 + \sigma_u^2)$, $\lambda = \frac{\sigma_u}{\sigma_v}$, *Log is* Log Likelihood. Estimates based on Battese and Coelli (1995) model using Limdep10 software.

Table 5.2 shows that the parameters of the normalised input prices are positive and significantly different from zero, while the coefficients of the outputs show mixed results. According to the main model (Model 1), the profit elasticity with regard to total loans (y_1) is 0.58, suggests that, on average, a 1% increase in total loans will increase pre-tax profits by about 0.58%, similar results can be obtained in Model 2 and Model 3, while this coefficient is not significant in Model 4. Similarly, the results indicate that a 1% increase in the amount of other earning assets (y_2) will lead to an increase by 0.38% in profits according to Model 1, and similar results can be concluded from the other models. It can also be seen that an increase by 1% in the off-balance sheet items (y_3) will increase profits in the four models, the magnitude of this increase is small though and the sign is not highly significant. With regard to input prices, it can be seen from Table 5.2 that the estimated coefficient of the price of labour (w_1) suggests that a 1% increase in the price of labour will increase profits by 0.57% in Model 1, and the magnitude of this increase is the largest in Model 3 and smallest in Model 4. Correspondingly, an increase by 1% in the price of physical capital (w_2) will raise profits by 0.15% in Model 1, however; it is notable that the magnitude of this coefficient is smaller than that of the price of labour in all models. The coefficients of the equity ratio (risk preference) are negative and statistically significant in all models, meaning that an increase in the amount of equity relative to total assets will decrease profits.

Table 5.2, also, includes the other parameters that were already explained above in the case of cost frontier, in the last five rows. Gamma values are smaller in the case of profit efficiency than cost efficiency, and range from 0.85 in Model 1 to 0.75 in Model 4, meaning that the variation of inefficiency is more important than other stochastic variations based on the common frontier and based on the separate frontier too. Lambda is positive and highly significant in all models and is higher than unity in all models except Model 4. Eta is positive and significant for all models meaning that inefficiency tends to decrease with time for all the models. Finally, the log likelihood functions are shown in the last row of the table.

5.3 Bank Efficiency Levels

In this section, we present cost and profit efficiencies estimates of the four EU country groups when estimating a common frontier for all of them and separate frontiers for each of the groups. We also report average cost and profit efficiencies' estimates for all the 27 countries individually and for each of the four country groups over the seven years under study along with the rank of each country based on the common frontier. This will indicate the level of EU banking system cost and profit efficiencies for all years between 2004 and 2010 and sheds light on which EU groups perform better than the others with the emphasis being on comparing the old and the new EU member states.

5.3.1 Cost Efficiency Levels

Table 5.3 provides the mean cost efficiency estimates of all the EU country groups based on a common frontier and based on separate frontiers over the period 2004-2010. In the last row we show the results of the Mann-Whitney[36] test that we run in order to examine whether the differences in the mean cost efficiency for the three EU groups, the old EU countries (EU15), the new EU countries (EU12) and the GIIPS countries (EUGIIPS) are significantly different based on common and separate frontiers. It can be noted from the table that overall the cost efficiency scores based on separate frontiers are higher than the efficiency scores generated using a common frontier and the difference is more obvious in the case of the new EU states and the GIIPS countries. This is not surprising as using separate frontiers allow for the country-specific differences related to banking technology, environment and regulatory conditions among the EU country groups, and hence it raises the efficiency scores of most banks since the common frontier is actually a frontier of frontiers[37]. Furthermore, and using a common frontier, it can be seen from Table 5.3 that the average cost efficiency for the entire EU stands at 73.4%, meaning that commercial banks in the EU could reduce their costs by almost 27% on average, in order to match their performance with the best practice commercial banks in the sample. On the other hand, the mean cost efficiency is 74%, 70.9% and 79.8% for the old EU countries, the

[36] Mann-Whitney (Wilcoxon rank-sum) test is a nonparametric test that compares two-independent samples [for more, see Spatz (2010)].
[37] See Maudos *et al*. (2002b) and Dietsch and Lozano-Vivas (2000).

new EU countries, and the GIIPS countries, respectively. This suggests that, on average, commercial banks in the GIIPS countries are more cost efficient than their counterparts in the other EU countries over the period from 2004 to 2010, whereas commercial banks in the new EU member states are the least cost efficient banks in the EU over the same period of time. Using separate cost frontiers, Table 5.3 shows that the level of cost efficiency increases from 70.9% and 79.8% to 81.3% and 83.4% for the new EU countries and the GIIPS countries, respectively, while for the old EU countries the efficiency level decreases slightly. However, the Mann-Whitney test show that the differences in the mean efficiency scores generated using both common and separate frontiers are only significant (at 1%) in the cases of the new EU countries and the GIIPS countries while they appear to be insignificant in the case of the old EU countries. It can be concluded here that commercial banks in the EU member states still have room for cost efficiency improvement by producing the same level of outputs with lower costs or by producing more outputs using the same level of costs.

Table 5.3 Cost Efficiency Estimates: Common *Vs.* Separate Frontiers

Year	**Common Frontier**				**Separate Frontiers**		
	EU27	**EU15**	**EU12**	**EUGIIPS**	**EU15**	**EU12**	**EUGIIPS**
2004	0.721	0.736	0.675	0.787	0.755	0.812	0.816
2005	0.737	0.750	0.687	0.798	0.738	0.816	0.848
2006	0.734	0.742	0.701	0.797	0.730	0.814	0.840
2007	0.739	0.746	0.716	0.818	0.732	0.807	0.840
2008	0.732	0.731	0.736	0.798	0.733	0.822	0.835
2009	0.732	0.735	0.722	0.786	0.729	0.811	0.825
2010	0.737	0.743	0.717	0.797	0.735	0.813	0.838
Mean	0.734	0.740	0.709	0.798	0.736	0.813	0.834
MW-*test* (P>Z)					0.114	0.000	0.000

Author's calculations.

To look deeper into cost efficiency of commercial banks in the EU member states, Table 5.4 summarises, using a common frontier as it is the main model in this study, the mean efficiency scores of banks for each of the EU countries and the evolution of cost efficiency over the period under study (efficiency evolution to be discussed in section

5.4). The reason for presenting the efficiency scores based only on the common frontier in Table 5.4 is to provide a logical comparison between the levels of cost efficiency between the 27 EU countries in this thesis. The table shows that the mean cost efficiency estimates of commercial banks in the EU range from its highest value at 90.1% in Sweden to its lowest value at 55.1% in Luxembourg over the years from 2004 to 2010, meaning that commercial banks could reduce their costs by almost 10% in Sweden and by about 45% in Luxembourg in order to operate on the cost frontier. The table also shows that along with Sweden, Denmark (85.5%) and Greece (85.4%) are the most efficient, while Romania (63.1%) and Slovakia (65.3%) join Luxembourg to have the least cost efficient banking sectors in the EU. Furthermore, from the table we can see that cost efficiency level increases in Bulgaria and Romania from the year they joined the EU (2007) onward. This might indicate rather convergence or catching up between banks in these two countries and the other EU member states in terms of banking performance as they joined the EU.

Table 3a in Appendix 3 provides the mean efficiency scores of banks for each of the EU groups and the evolution of cost efficiency over the period under study while in the last row the cost efficiency gap between banking sectors in the old EU states and the new EU states is provided. It can be seen that there exists an efficiency gap between the two groups and it has a decreasing trend, overall, over the study period as it declines from 0.061 in 2004 to 0.026 in 2010 (by 56.64%). Moreover, the table shows that this gap reaches its smallest value at the time of the global crisis and particularly in 2008 where the efficiency gap becomes negative (-0.005), meaning that the efficiency of banks in the new EU states exceeds slightly the efficiency of their counterparts in the old EU states. However, the cost efficiency gap returns to increase in 2009 and 2010 making an overall average of 0.032 for the entire period under study. Hence, it can be concluded that the new EU countries managed to reduce the cost efficiency gap and catch up with the old EU states over time. The higher level of cost efficiency in the old EU countries overall might be attributed to the idea that banks in the old countries operate in a higher level of competition which imposes pressure on them to reduce their costs. Also, better technology and management techniques and expertise obtained by banks and more developed and competitive capital markets in these countries might support these banks to maintain higher levels of cost efficiency compared to banks in the new EU states. In the next chapter we thoroughly analyse potential environmental causes behind differences in efficiency among banks and across countries.

This result stands in line with what Hollo and Nagy (2006) concluded in their study on banking efficiency in the enlarged European Union that the new EU countries experienced a rapid catching-up process with the old EU countries over the period 1999-2003. Also, this result is similar to the result obtained by Weill (2003a) in which he finds that Western European countries are more cost efficient than Eastern European countries, though the latter group manage to decrease the efficiency gap with the first group between 1996 and 2000. Furthermore, it can be emphasised that if banks in the new EU states improved their cost efficiency prior to the year 2004, as proven by Hollo and Nagy (2006), when ten of these countries had to meet different financial and economic criteria to joined the EU (as discussed in Chapter 2), the bank efficiency in these countries has not worsened after these countries became members of the EU in the post-2004 period.

Table 5.4 Cost Efficiency Estimates and Evolution										
Country	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**Evolution %**	**Average (All)**	**Rank**
Austria	0.743	0.743	0.753	0.749	0.713	0.704	0.748	+0.70	0.736	14
Belgium	0.769	0.774	0.761	0.718	0.701	0.701	0.833	+8.23	0.748	11
Bulgaria	0.632	0.619	0.600	0.681	0.723	0.716	0.689	+9.03	0.669	23
Cyprus	0.791	0.814	0.832	0.818	0.816	0.773	0.753	-4.82	0.806	6
Czech. R	0.639	0.629	0.646	0.648	0.703	0.722	0.712	+11.58	0.670	22
Denmark	0.843	0.841	0.855	0.871	0.871	0.854	0.846	+0.36	0.855	2
Estonia	0.751	0.835	0.791	0.791	0.751	0.658	0.628	-16.42	0.744	12
Finland	0.790	0.614	0.626	0.617	0.690	0.678	0.645	-18.33	0.660	24
France	0.823	0.781	0.781	0.760	0.761	0.780	0.788	-4.27	0.781	8
Germany	0.720	0.729	0.701	0.708	0.682	0.691	0.689	-4.22	0.704	17
Greece	0.840	0.825	0.866	0.869	0.876	0.856	0.866	+3.20	0.854	3
Hungary	0.700	0.688	0.624	0.687	0.744	0.697	0.678	-3.21	0.694	19
Ireland	0.597	0.738	0.769	0.745	0.745	0.608	0.617	+3.26	0.697	18
Italy	0.740	0.790	0.790	0.813	0.803	0.811	0.813	+9.98	0.802	7
Latvia	0.648	0.710	0.753	0.751	0.772	0.722	0.676	+4.38	0.721	16
Lithuania	0.694	0.716	0.736	0.765	0.813	0.750	0.732	+5.59	0.743	13
Luxembourg	0.542	0.553	0.556	0.554	0.540	0.548	0.576	+6.35	0.551	27
Malta	0.766	0.768	0.781	0.728	0.777	0.741	0.780	+1.85	0.762	10
Netherlands	0.737	0.690	0.658	0.690	0.671	0.671	0.666	-9.57	0.682	20
Poland	0.713	0.705	0.746	0.701	0.724	0.724	0.741	+3.89	0.722	15
Portugal	0.812	0.735	0.727	0.802	0.774	0.813	0.780	-3.94	0.777	9
Romania	0.600	0.598	0.602	0.649	0.663	0.654	0.661	+10.19	0.631	26
Slovakia	0.579	0.630	0.645	0.686	0.622	0.691	0.716	+23.72	0.653	25
Slovenia	0.808	0.815	0.824	0.863	0.868	0.854	0.865	+6.99	0.841	4
Spain	0.815	0.832	0.836	0.854	0.791	0.758	0.828	+1.58	0.814	5
Sweden	0.923	0.916	0.922	0.910	0.872	0.884	0.881	-4.60	0.901	1
UK	0.651	0.693	0.670	0.699	0.694	0.691	0.662	+1.75	0.681	21

5.3.2 Profit Efficiency Levels

Table 5.5 provides the means of profit efficiency estimates of the four EU country groups based on a common frontier and based on separate frontiers for the period under study. The table shows that, similar to the case of cost efficiency, using separate profit frontiers generates higher estimates than using a common frontier for the groups of the new EU states and the GIIPS countries, while it generates slightly lower estimates, on average, in the case of the old EU countries. As stated earlier above, this should not be surprising as using separate frontiers takes country differences into consideration. Furthermore, it can be noted that profit efficiency scores are, on average, lower than cost efficiency scores for all the four groups whether a common frontier is used or separate frontiers. This indicates the importance of considering the revenue side in measuring efficiency that is not taken into account when concentrating only on the cost side. This result is common to the few studies that compare bank cost efficiency and profit efficiency, such as Hollo and Nagy (2006) and Maudos *et al*. (2002a) for the case of European banking systems and Berger and Mester (1997) in the case of US banking system.

Based on a common frontier, it can be seen from Table 5.5 that the mean profit efficiency score for the entire EU stands at 57.1%, meaning that commercial banks in the EU could increase their profits by about 43%, on average, to catch up with the best practice banks. On the other hand, the mean profit efficiency is 56%, 60.9%, and 61.6% for the old EU countries, the new EU countries, and the GIIPS countries, respectively. This suggests that, on average, commercial banks in the GIIPS countries, as in the case of cost efficiency, are more profit efficient than their counterparts in the other EU countries over the seven years under study, whereas banks in the old EU states (EU15) are the least profit efficient banks in the EU over the same period of time. Using separate frontiers to estimate profit efficiency, Table 5.5 indicates that the level of profit efficiency rises to 61.3% and 66.5% for the new EU countries and the GIIPS countries, respectively, while it declines to 55.3% in the case of old EU countries. However, the Mann-Whitney test provided in the last row in the table shows that the differences in the mean profit efficiency scores generated using both common and separate frontiers are only significant (at 1%) in the case of the GIIPS countries while they appear to be insignificant in the cases of the old and new EU countries. It can be concluded that banking sectors in the new EU states domain their counterparts in the old EU states in terms of profit efficiency over the period 2004-2010. In addition, it can be said that the room for commercial banks in the EU to improve their profit efficiency is larger than it is to improve their cost efficiency. Improving profit efficiency can be done by generating more revenues using the same level of input prices or generating the same level of revenues using lower input prices.

Table 5.5 Alternative Profit Efficiency Estimates: Common *Vs.* Separate Frontiers							
Year	**Common Frontier**				**Separate Frontiers**		
	EU27	**EU15**	**EU12**	**EUGIIPS**	**EU15**	**EU12**	**EUGIIPS**
2004	0.571	0.560	0.602	0.652	0.553	0.616	0.651
2005	0.576	0.563	0.625	0.609	0.562	0.605	0.667
2006	0.582	0.568	0.637	0.618	0.549	0.610	0.674
2007	0.551	0.537	0.603	0.595	0.563	0.608	0.659
2008	0.546	0.533	0.591	0.585	0.554	0.606	0.651
2009	0.568	0.563	0.584	0.628	0.544	0.621	0.663
2010	0.615	0.612	0.625	0.660	0.551	0.623	0.687
Mean	0.571	0.560	0.609	0.616	0.553	0.613	0.665
MW-test (P>Z)					0.202	0.740	0.000

Author's calculations.

To investigate further the level of bank profit efficiency in the EU, Table 5.6 summarises the mean efficiency scores for each of the EU countries and the evolution of efficiency estimates over time generated based on the common frontier, for the reason explained earlier above. The table shows that the mean profit efficiency score of commercial banks in the EU ranges from 74.3% in Bulgaria to 43.9% in Hungary over the study period, meaning that banks in Bulgaria could increase their profits by about 26% and by about 56% in Hungary in order to operate on the profit frontier. It can also be shown from the table that along with Bulgaria, Spain (74.2%) and Czech Republic (73%) are the most profit efficient, whereas Poland (46.4%) and Romania (48.3%) are the least profit efficient, along with Hungary. Moreover, contrary to the case of cost efficiency, profit efficiency in Bulgaria and Romania deteriorates in the year 2007 compared to the year 2006. This might be attributed to the higher level of competition or less market concentration in these two countries as they joined the EU, which in turn decreases banks' profits. Also, this efficiency deterioration might be caused or exacerbated by the events of the financial crisis.

In Table 3b in Appendix 3 the profit efficiency score for all the EU groups as well as the efficiency gap between banking sectors in the old EU countries and the new EU countries is provided. It can be seen that there exists an efficiency gap between the two groups but in favour of the new EU states, meaning that banking systems in these countries are slightly more profitable than their counterparts in the old EU countries. This may be caused by differences in the overall regulatory and macroeconomic environment in the two regions. For instance, banks in the new EU countries may operate in a more concentrated environment (less competition), allowing them to make higher profits compared to banks in the old countries. The next chapter sheds light on possible factors affecting efficiency in the EU banking system. The profit efficiency gap declines from 0.042 in 2004 to 0.012 in 2010 (by 70.57%), making an average of (0.048). The efficiency gap increased in 2005 and 2006 while the decline in this gap starts to take place in 2007 at the beginning of the global financial crisis and becomes more obvious in 2009 and 2010. Therefore, it can be concluded that commercial banks in the new EU member states are more profit efficient, on average, than commercial banks in the old EU member states over the period 2004-2010 although the magnitude of the efficiency gap is small, particularly in the end of the study period. This result is somewhat similar to that obtained by Hollo and Nagy (2006) particularly in their uncontrolled model but not in their controlled model (where some operational environmental variables are included in profit function). It can also be said here that if commercial banks in the new EU states were more profit efficient than their counterparts in the old EU states in the period prior to 2004, as concluded by Hollo and Nagy (2006), when ten of them had to meet financial and economic criteria to join the EU, they persisted to be more profit efficient, on average in the period following 2004 and their performance has not evidently deteriorated.

Country	2004	2005	2006	2007	2008	2009	2010	Evolution %	Average (All)	Rank
Austria	0.623	0.613	0.619	0.582	0.594	0.583	0.661	+6.00	0.608	12
Belgium	0.541	0.559	0.544	0.544	0.486	0.537	0.676	+25.08	0.547	20
Bulgaria	0.716	0.729	0.761	0.734	0.745	0.759	0.764	+6.68	0.743	1
Cyprus	0.478	0.494	0.543	0.548	0.539	0.534	0.629	+31.67	0.529	21
Czech. R	0.755	0.723	0.732	0.711	0.742	0.735	0.723	-4.17	0.730	3
Denmark	0.580	0.575	0.582	0.529	0.512	0.526	0.566	-2.41	0.552	19
Estonia	0.742	0.734	0.761	0.757	0.740	0.669	0.635	-14.35	0.722	4
Finland	0.591	0.514	0.523	0.487	0.592	0.608	0.592	+0.19	0.562	18
France	0.515	0.495	0.483	0.449	0.465	0.495	0.525	+1.89	0.488	24
Germany	0.512	0.503	0.515	0.495	0.479	0.506	0.573	+11.97	0.509	23
Greece	0.550	0.551	0.599	0.563	0.591	0.631	0.590	+7.38	0.583	15
Hungary	0.460	0.477	0.469	0.395	0.444	0.423	0.451	-1.85	0.439	27
Ireland	0.779	0.732	0.697	0.611	0.601	0.666	0.657	-15.58	0.663	9
Italy	0.554	0.553	0.552	0.540	0.547	0.583	0.638	+15.06	0.565	17
Latvia	0.701	0.691	0.688	0.651	0.613	0.585	0.633	-9.77	0.651	11
Lithuania	0.705	0.718	0.734	0.697	0.693	0.625	0.739	+4.81	0.701	6
Luxembourg	0.519	0.528	0.522	0.486	0.492	0.524	0.591	+14.04	0.518	22
Malta	0.720	0.720	0.731	0.626	0.608	0.641	0.746	+3.71	0.676	8
Netherlands	0.604	0.515	0.582	0.540	0.620	0.609	0.647	+7.05	0.593	14
Poland	0.494	0.494	0.514	0.448	0.412	0.431	0.499	+0.92	0.464	26
Portugal	0.712	0.554	0.576	0.494	0.553	0.623	0.608	-14.60	0.582	16
Romania	0.448	0.487	0.521	0.499	0.496	0.445	0.474	+5.81	0.483	25
Slovakia	0.645	0.683	0.660	0.647	0.649	0.648	0.689	+6.82	0.660	10
Slovenia	0.611	0.652	0.667	0.702	0.707	0.713	0.701	+14.80	0.679	7
Spain	0.738	0.733	0.781	0.769	0.692	0.712	0.794	+7.68	0.742	2
Sweden	0.740	0.746	0.765	0.709	0.652	0.681	0.728	-1.71	0.714	5
UK	0.613	0.613	0.625	0.579	0.562	0.594	0.645	+5.26	0.603	13

Table 5.6 Alternative Profit Efficiency Estimates and Evolution

5.3.3 Cost and Profit Efficiency Levels and Bank Size:

In order to investigate the relationship between bank size and cost and profit efficiencies according to the common frontier of the entire EU region, we divide banks into five different categories on the basis of the size of their total assets. A bank is classified as a very large bank if its total assets are greater than USD$500bn, a large bank if USD$100-

500bn , a medium bank if USD$10-100bn , a small bank if USD$1-10bn and a very small bank if its assets are less than USD$1bn. The average cost and profit efficiency scores for the five asset size groups of EU banks over the seven years under study are shown in Table 5.7.

Table 5.7 Average Cost and Profit Efficiencies by Size Groups

Year	***Very Large Banks***		***Large Banks***		***Medium Banks***		***Small Banks***		***Very Small Banks***	
	Cost	*Profit*	*Cost*	*Profit*	*Cost*	*Profit*	*Cost*	*Profit*	*Cost*	*Profit*
2004	0.667	0.696	0.721	0.664	0.654	0.539	0.725	0.565	0.736	0.576
2005	0.655	0.680	0.757	0.667	0.708	0.557	0.735	0.576	0.751	0.574
2006	0.661	0.677	0.758	0.623	0.683	0.563	0.737	0.581	0.760	0.580
2007	0.653	0.634	0.758	0.589	0.716	0.533	0.741	0.546	0.761	0.557
2008	0.655	0.633	0.780	0.608	0.685	0.526	0.742	0.549	0.750	0.535
2009	0.677	0.643	0.756	0.613	0.705	0.547	0.740	0.578	0.739	0.552
2010	0.681	0.664	0.759	0.633	0.720	0.598	0.753	0.628	0.730	0.594
Mean	0.664	0.655	0.760	0.620	0.699	0.552	0.739	0.572	0.747	0.567
Obs	*108*	*108*	*144*	*144*	*778*	*778*	*1944*	*1944*	*1276*	*1276*

Author's calculations.

As can be seen from the table, large banks appear to be the most cost efficient banks among all the groups with average cost efficiency of 76%, while the very large banks are the most profit efficient banks in the sample with average profit efficiency of about 66%. It can be concluded here that larger banks are more efficient because they might have exploited economies of scale, adopted more advanced technology and management expertise, or employed specialised staff as well as implemented extensive network of branches (Hunter and Timme, 1986). However, as the very large banks appear the most profit efficient, they are also the least cost efficient banks, suggesting that as these banks generate more profits, they feel less pressure to minimise their costs compared to all the other groups. On the other hand, small banks and the very small banks appear to be more cost and profit efficient than medium-sized banks on average. This might be due to the fact that smaller banks tend to operate more in local markets and also exercise some monopoly power. These banks might obtain more profits than medium-sized banks due to the lack of adequate level of competition. Furthermore, it might be easier for smaller banks to engage in "relationship" banking than larger banks, which are headquartered in metropolitan centres, as this type of lending requires local knowledge of clients' financial needs, which might be more accessible to smaller banks (Mamatzakis *et al*., 2008).

5.4 Bank Efficiency Evolution

It is vital to investigate the evolution of bank efficiency for the EU countries to see whether they have improved their efficiency over the period 2004-2010 or they have failed to do so. This presents dynamic analysis of cost and profit efficiencies of the four EU country groups and sheds light on the dynamic efficiency gaps between the groups, particularly between the new and old EU states. Table 5.4 and Table 5.6 above show the evolution of mean cost and profit efficiency scores for all EU countries over the time period under study. The evolution number in the ninth column is calculated as the difference between the average efficiency score in 2004 and the average efficiency score in 2010 and is presented in percentage. With regard to cost efficiency, Table 5.4 provides mixed results for the efficiency evolution values of the 27 EU countries with some countries experience positive evolution and others experience negative evolution. The Slovakian banking system has the highest percentage of positive cost efficiency evolution (+23.72%) between 2004 and 2010, meaning that commercial banks in Slovakia, on average, increased their cost efficiency level by 23.72% over the seven-year period under study. On the other hand, the commercial banking system in Finland experiences the highest percentage of negative cost efficiency evolution (-18.33%) over time, meaning that bank cost efficiency in Finland deteriorated over the period under study. However, it can be noticed from Table 5.4 that only nine of the EU countries exhibit negative cost efficiency evolutions; with Finland (-18.33%) and Estonia (-16.42%) have the highest percentage of negative evolution, while the rest of the EU countries exhibit positive cost efficiency evolution, with Slovakia (+23.72%) and Czech Republic (+11.58%) have the highest percentage of cost efficiency evolution.

Table 3a in Appendix 3 incorporates the percentages of cost efficiency evolution in the banking systems of the four EU country groups we adopt in this study as well as the evolution of the efficiency gap between the old and the new EU member states. Overall, all the four groups experience a positive percentage of cost efficiency evolution between 2004 and 2010, or in other words, there is an improvement in the average cost efficiency in the four groups. The highest percentage is exhibited by the new EU countries and stands at +6.13%, meaning that commercial banks in these countries improved their cost efficiency, on average, by 6.13% over the seven years. Contrary to the new EU states, the old EU states could increase their cost efficiency by only 0.95% whereas the GIIPS countries show an overall positive evolution of about 1.32%. The entire EU banking system shows a positive cost efficiency evolution of 2.21% while the efficiency gap between the old and the new EU member states has decreased by 56.64% between 2004 and 2010, as stated in the last row in Table 3a.

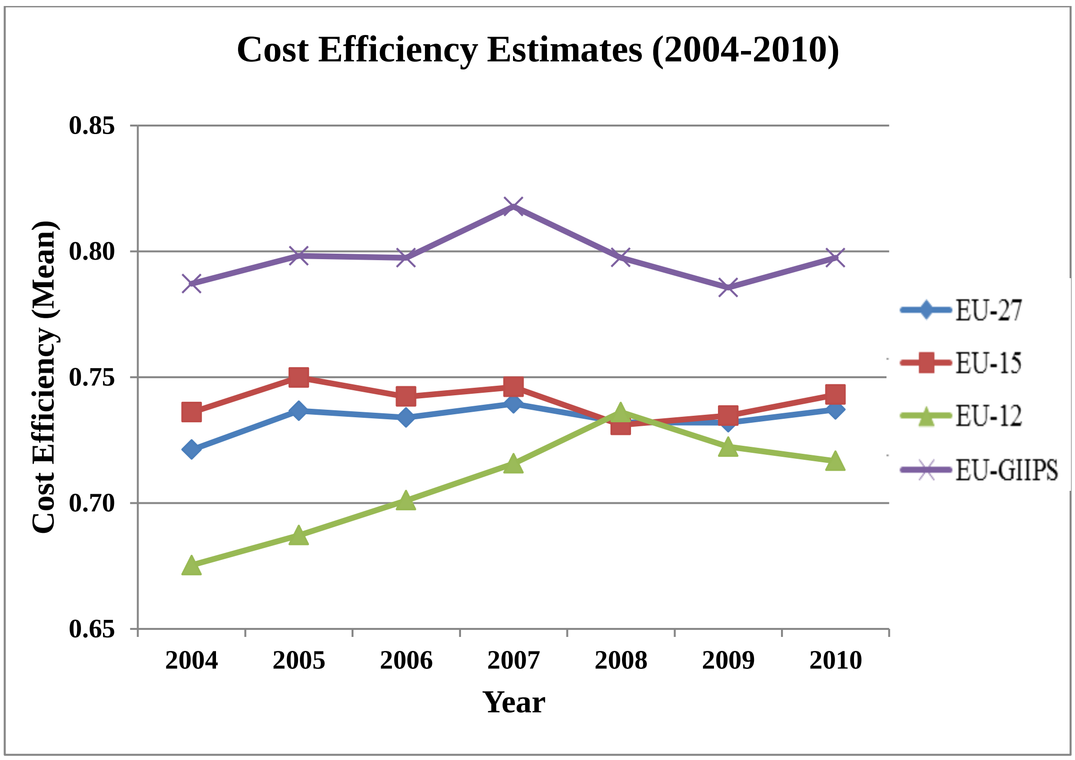

Figure 5.1. Cost Efficiency Estimates of EU Banks (2004-2010)

Figure 5.1 shows the trends of the mean cost efficiency estimates for the EU country groups over the period from 2004 to 2010. It can be seen from the figure that the GIIPS countries maintain the highest level of cost efficiency over the seven years under study and this level peaks in 2007 and start to decline after that over the global financial crisis

(2007-2009). While the efficiency trend representing the old EU countries (EU15) does not fluctuate a lot over time, it exhibits a slight decline during the crisis time; particularly between 2007 and 2008. The efficiency trend of the new EU countries increases significantly between 2004 and 2008; the year in which it catches up and slightly exceeds the trend of the old EU states, before it starts to decline steadily afterwards. Overall, the cost efficiency trend of the entire EU area does not show clear fluctuations over time, it rises in the beginning of the period and declines slightly between 2007 and 2008 though. It can be concluded from the analysis of cost efficiency evolution that a convergence between the old and the new EU member states might exist over the seven-year period.

Concerning profit efficiency, Table 5.6 also provides mixed results as to the evolution of profit efficiency of the 27 EU countries over the seven years under study with some countries experiencing positive evolution and others experiencing negative evolution. The highest percentage of positive profit efficiency evolution is obtained by Cyprus and stands at +31.67%, meaning that the commercial banking system in Cyprus increased its profit efficiency by 31.67% between 2004 and 2010. On the other hand, the commercial banking system in Ireland exhibits the highest percentage of negative efficiency evolution (-15.58%) over time, meaning that bank profit efficiency in Ireland deteriorated by this percentage over the period under study. As can be seen from Table 5.6, only eight EU countries exhibit negative profit efficiency evolutions; with Ireland (-15.58%), Estonia (-14.35%) and Portugal (-14.60%) have the highest negative evolution numbers, whereas the rest of the EU countries exhibit positive efficiency evolutions; with Cyprus (+31.67%) and Belgium (+25.08%) have the highest positive evolution numbers.

Table 3b in Appendix 3 contains the percentages of profit efficiency evolution in the banking systems for the four EU groups as well as the evolution of the efficiency gap between the old and the new EU states. The evolution numbers in the case of profit efficiency are different from those reported in the case of cost efficiency, the evolution numbers are positive in both cases though meaning that there is an improvement in the average profit efficiency for all the groups. The old EU countries show a much higher percentage of profit efficiency evolution that stands at +9.26%, meaning the commercial banks in the old EU countries succeeded in raising their profit efficiency, on average, by

9.26% between 2004 and 2010. On the other hand, the new EU members show lower profit efficiency evolution (+3.75%) than cost efficiency evolution (+6.13%) over the same period of time. The GIIPS countries exhibit rather similar profit efficiency evolution (+1.18) to the cost efficiency evolution (+1.32%), while the entire EU region show a profit efficiency evolution of +7.79% compared to +2.21% evolution in the case of cost efficiency. Finally, the evolution of profit efficiency gap between the old and the new EU member states, with the new EU countries being more profit efficient, is -70.57%, meaning that a reduction of 70.57% in profit efficiency gap took place between 2004 and 2010 in favour of the old EU countries.

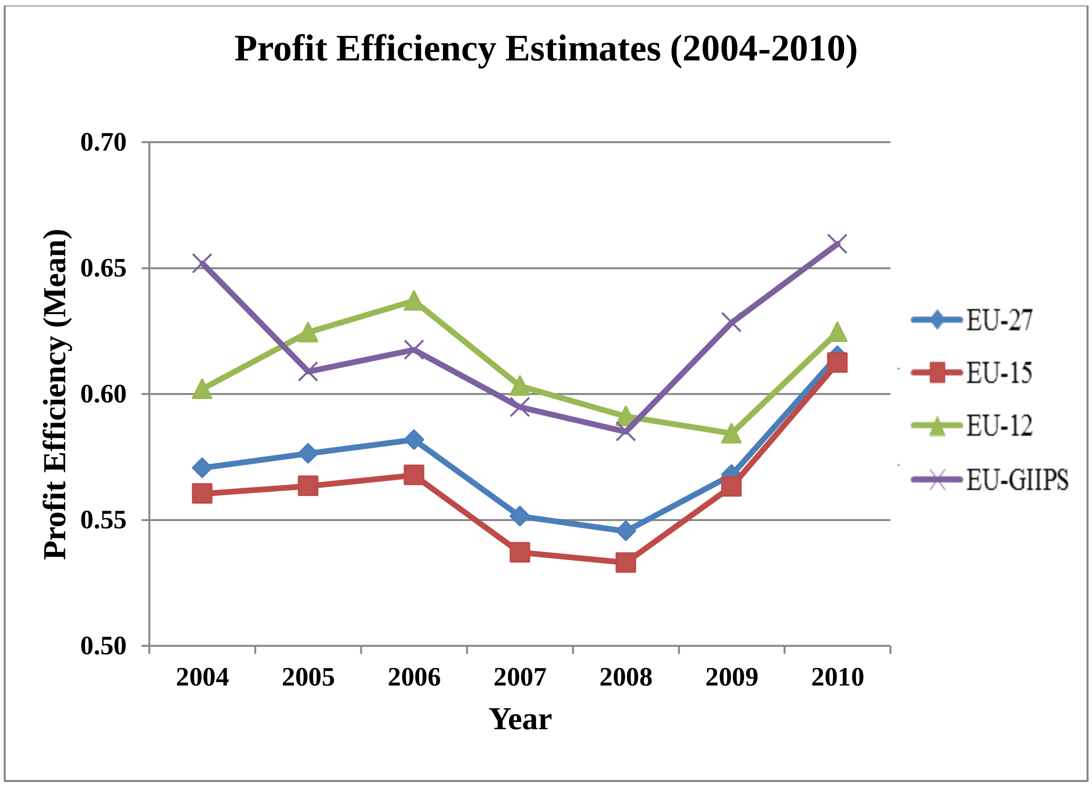

Figure 5.2. Profit Efficiency Estimates of EU Banks (2004-2010)

Figure 5.2 above shows the trends of mean profit efficiency estimates for the four EU country groups over the years from 2004 to 2010. Contrary to what Figure 5.1 shows with regard to cost efficiency trends, the EU groups in Figure 5.2 show similar trends with regard to the level of profit efficiency over the seven years under study. It can be seen from the figure that commercial banks in the old EU countries show the lowest level of profit efficiency, on average, over the entire time period of study, while the new EU countries and the GIIPS countries compete with each other with reference to profit efficiency over time. It is worth noting that the level of profit efficiency starts to decline after 2006 in all the four groups and reaches its lowest value at 2008 for all the groups, except for the new EU countries where profit efficiency reaches its lowest value in 2009. Therefore, the effect of the global financial crisis is obvious in this figure where the trends show a clear decline between 2007 and 2008 for the old EU countries and the GIIPS countries and between 2007 and 2009 for the new EU member states. However, the level of profit efficiency exhibits a clear increase at the end of the period, particularly between 2008 and 2010 for the old EU members and the GIIPS countries and between 2009 and 2010 for the new EU members. The trend of profit efficiency for the entire EU area remains lower than the trends of the new EU countries and the GIIPS countries, on average, over the entire period of time in this study. Therefore, the analysis of profit efficiency evolution might suggest the existence of convergence between the old and the new EU member states over the period under study and particularly in the last two years.

5.5 Dispersion of Bank Efficiency

We, also, investigate the divergence (heterogeneity) of bank efficiency within the groups of the old EU countries, the new EU countries, and the GIIPS countries as well as for the pooled sample of the entire EU member states. Figures 5.3 and 5.4 describe the standard deviation trend (dispersion) of cost efficiency and profit efficiency, respectively, for the four EU groups over the period from 2004 to 2010. Although measuring efficiency dispersion using the standard deviation gives a preliminary insight regarding convergence or integration, it is not a solid measure of efficiency convergence as it says little in statistical terms about convergence. As can be seen from Figure 5.3, there is no significant increase in the divergence of efficiency within any of the four EU groups over the period under study. The cost efficiency standard deviation increased slightly between 2004 and 2010 for the entire EU area and this increase is somewhat obvious during the time of the global crisis; particularly between 2007 and 2008, which can be attributed to the fact that commercial banks in the EU responded differently to the effects of the crisis. However, the dispersion trend shows a decrease between 2008 and 2010, meaning that the old and new EU countries might exhibit a convergence in cost efficiency in the last two years. The trend of the old EU countries follows similar behaviour, while the dispersion of efficiency in the new EU countries decreases significantly over time, meaning that commercial banks in the new EU members might have achieved efficiency convergence between each other over the period 2004-2010. Finally, the figure shows that the divergence in the GIIPS countries increases over the crisis time (between 2007 and 2009), while it reaches its lowest value in 2005 and 2007. Overall, it can be said that the dispersion of cost efficiency does not have a clear trend over time, although it decreases for all the EU groups at the end of the period under study.

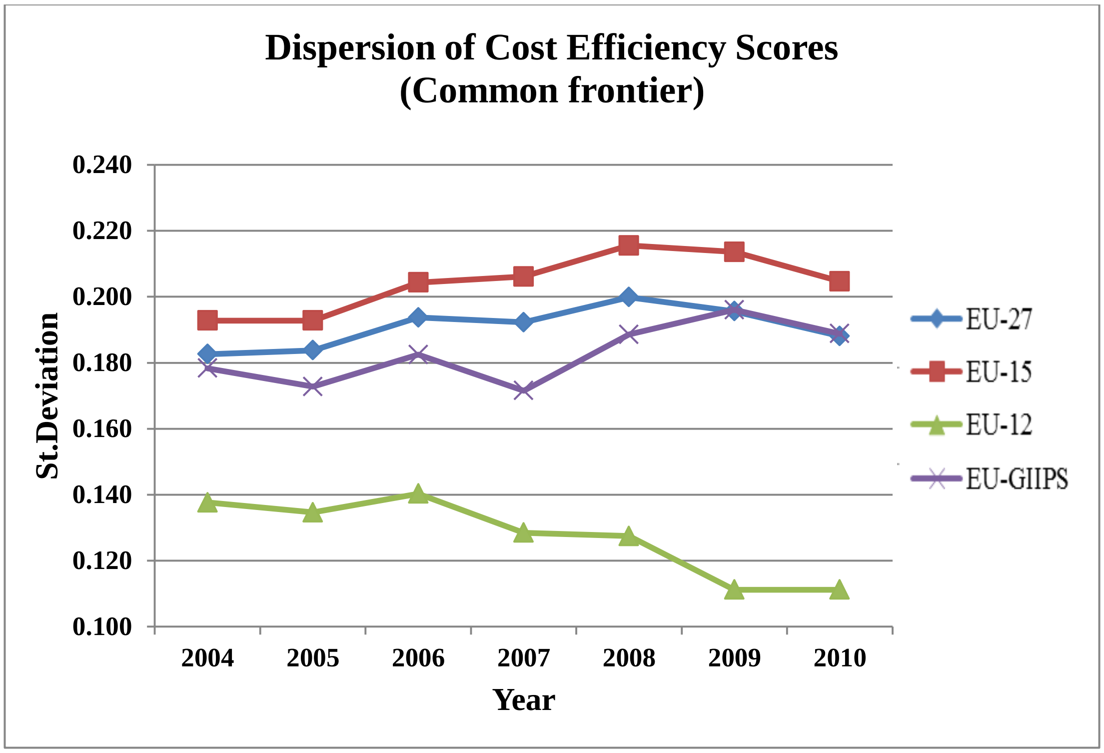

Figure 5.3. Dispersion of Bank Cost Efficiency (2004-2010)

With regard to the dispersion of profit efficiency, Figure 5.4 shows rather different trends of standard deviation, particularly for the GIIPS and for the new EU country groups. The profit efficiency dispersion of the entire EU and the old EU countries show similar trends that do not fluctuate significantly and remain almost the same in 2004 and 2010, however, they show a slight increase in 2007 and decrease in the last two years, probably indicating some convergence in efficiency. On the other hand, there are clear and significant fluctuations in the standard deviation of profit efficiency within the GIIPS countries and the new EU member states. The dispersion trend of profit efficiency in the GIIPS countries falls steeply in 2005 while it increases moderately until 2007 before it decreases, again, sharply over the crisis time (2007-2009), resulting in an overall decrease from 0.236 in 2004 to 0.185 in 2010. The dispersion trend of profit efficiency in the new EU countries shows a steeply decreasing trend between 2004 and 2006 while it rises sharply afterward in 2007 and falls significantly between 2009 and 2010, resulting in an overall decrease of about 0.011 between 2004 and 2010. Generally, it can be said that the divergence in profit efficiency either remains stable or declines in the four groups over time, while it decreases for all the EU groups, as in the case of cost efficiency, at the end of the period under study.

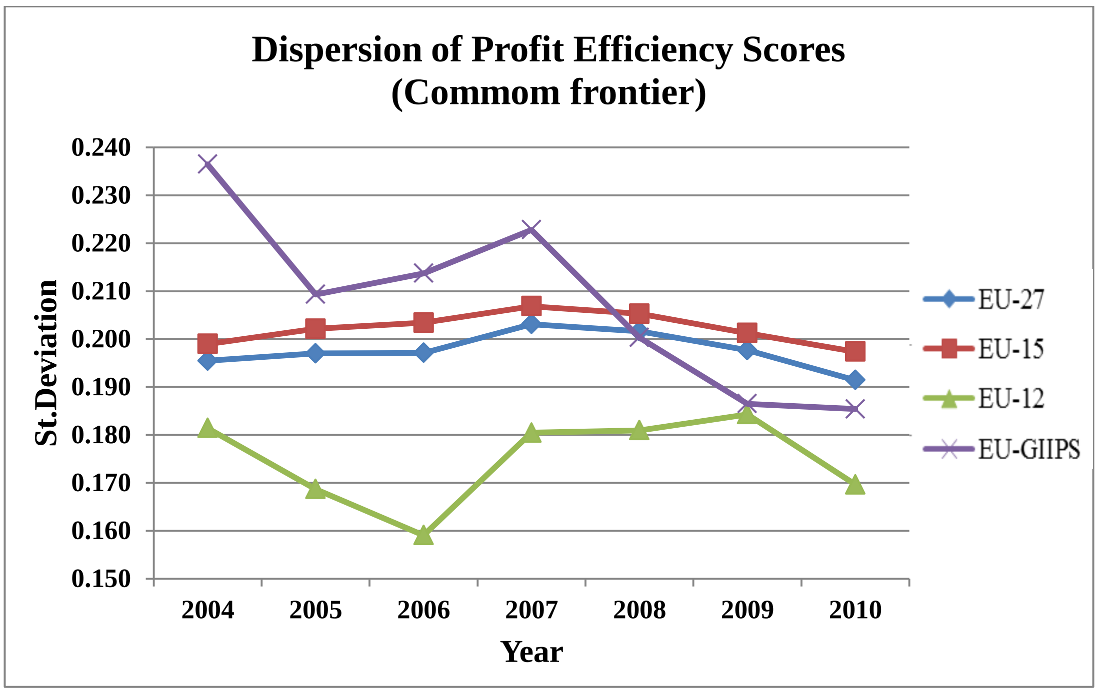

Figure 5.4. Dispersion of Bank Profit Efficiency (2004-2010)

5.6 Global Financial Crisis and Efficiency

We investigate the influence of the global financial crisis on bank cost and profit efficiency estimates over the period 2007-2009 for the entire EU region and for the other EU country groups utilised in this study. Tables 5.8 and 5.9 below provide average scores of cost and profit efficiencies respectively for the four EU groups during the crisis time, the non-crisis[38] time, and for the overall time period under study, in addition to the efficiency gap between the old and the new EU countries over the three time periods.

Table 5.8 Cost Efficiency Estimates and Crisis

Country	Average (Non-crisis)	Average (2007-2009)	Average (All)
EU27	0.736	0.731	0.734
EU15	0.745	0.735	0.740
EU12	0.706	0.712	0.709
EUGIIPS	0.800	0.796	0.798
Eff-gap	0.039	0.023	0.032

Author's calculations.

As can be indicated from Table 5.8, the mean cost efficiency score for the entire EU region over the crisis time (73.1%) is lower than the mean cost efficiency score in the non-crisis time (73.6%) and lower than the average efficiency score for the entire period from 2004-2010 (73.4%). The difference is even more significant when comparing the average cost efficiency level for the old EU members during the crisis time with the average cost efficiency level in the non-crisis time as the former stands at 73.5% and the latter stands at 74.5%. This means that the cost efficiency of commercial banks in the old EU countries is lower by about 1.36% during the crisis time than it is during the non-crisis time, on average. Similarly, the average efficiency score for the GIIPS countries over the crisis period (79.6%) is lower than the average cost efficiency in the non-crisis time (80%). On the other hand, the table shows that the average cost efficiency score for the new EU countries is higher during the crisis time, while it stands at 70.6% in the non-crisis time, it stands at 71.2% during the global crisis period. The magnitude of cost efficiency gap between the old and the new EU countries is reduced during the crisis (from 3.9% to 2.3%), meaning that banks in the new EU states managed to narrow the efficiency gap with banks in the old EU states. It can be concluded from this analysis that

[38] As the focus on this thesis is on the global financial crisis (2007-2009), therefore, non-crisis period includes the years from 2004 to 2006 as well as the year 2010.

the global financial crisis affected negatively the cost efficiency of commercial banks in the old EU countries over the period 2007 to 2009, whereas it can be said that commercial banks in the new EU countries decreased their total costs during the crisis time. Therefore, the global crisis influenced the cost efficiency of banks differently, depending on their regional belonging; whether they operated in the old EU members or in the new EU members. Figure 5.5 below depicts the aforementioned analysis of the effect of the financial crisis on the average of cost efficiency by the four country groups. The figure shows how the level of cost efficiency is lower during the crisis time than it is in the non-crisis time for all the groups except for the new EU countries.

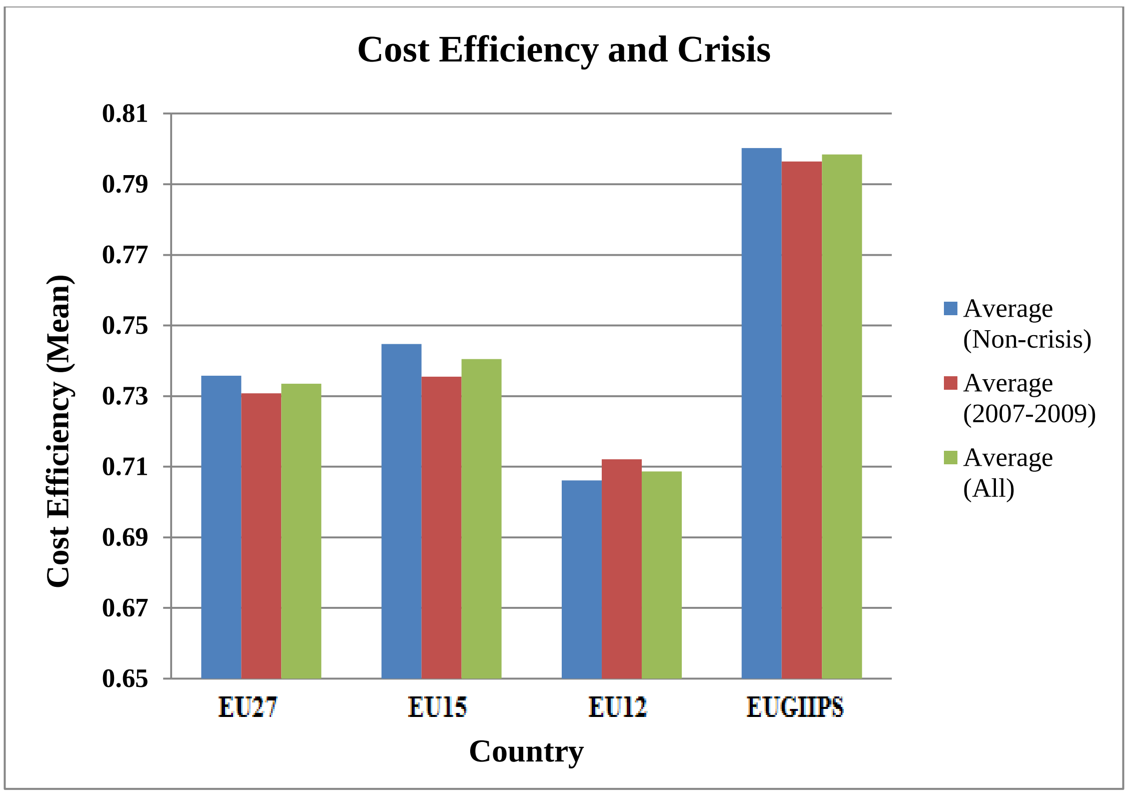

Figure 5.5. Bank Cost Efficiency and the Financial Crisis

Table 5.9 Profit Efficiency Estimates and Crisis			
Country	**Average (Non-crisis)**	**Average (2007-2009)**	**Average (All)**
EU27	0.588	0.550	0.571
EU15	0.575	0.543	0.560
EU12	0.630	0.579	0.609
EUGIIPS	0.627	0.603	0.616
Eff-gap	-0.055	-0.035	-0.048

Author's calculations.

With regard to profit efficiency, the effect of the world financial crisis is more obvious that it is in the case of cost efficiency. As can be shown from Table 5.9 above, the mean profit efficiency score for the entire EU region over the crisis time is 55%, whereas it is higher and stands at 58.8% in the non-crisis time and at 57.1% for the entire period from 2004 to 2010. A similar result is obtained for the average profit efficiency of banks in the old EU member states which is lower over the crisis time (54.3%) than it is during the non-crisis time (57.5%), meaning that profit efficiency is, on average, lower by 5.89% during the crisis time that it is during the non-crisis time. Correspondingly, the average profit efficiency score for the GIIPS countries over the crisis period (60.3%) is lower than the average efficiency in the non-crisis time (62.7%). Contrary to the case of cost efficiency, bank profit efficiency in the new EU countries shows a lower level during the crisis time than its level during the non-crisis time, and while the former stands at 57.9%, the latter stands at 63.0%. Finally, the magnitude of profit efficiency gap between the old and the new EU member states is lower during the crisis time (3.5%) that it is in the non-crisis time (5.5%), this means that commercial banks in the old EU members could narrow the gap in profit efficiency with the new EU members. It can be concluded that the global financial crisis affected negatively bank profit efficiency in all the EU country groups we adopt in this study. Figure 5.6 below indicates a clear effect of the world financial crisis on bank profit efficiency in the four country groups. It can be clearly seen how the level of bank profit efficiency during the crisis time (2007-2009) is lower than both its level over the non-crisis time and its overall average of profit efficiency over the seven years under study for all the country groups tested in this study.

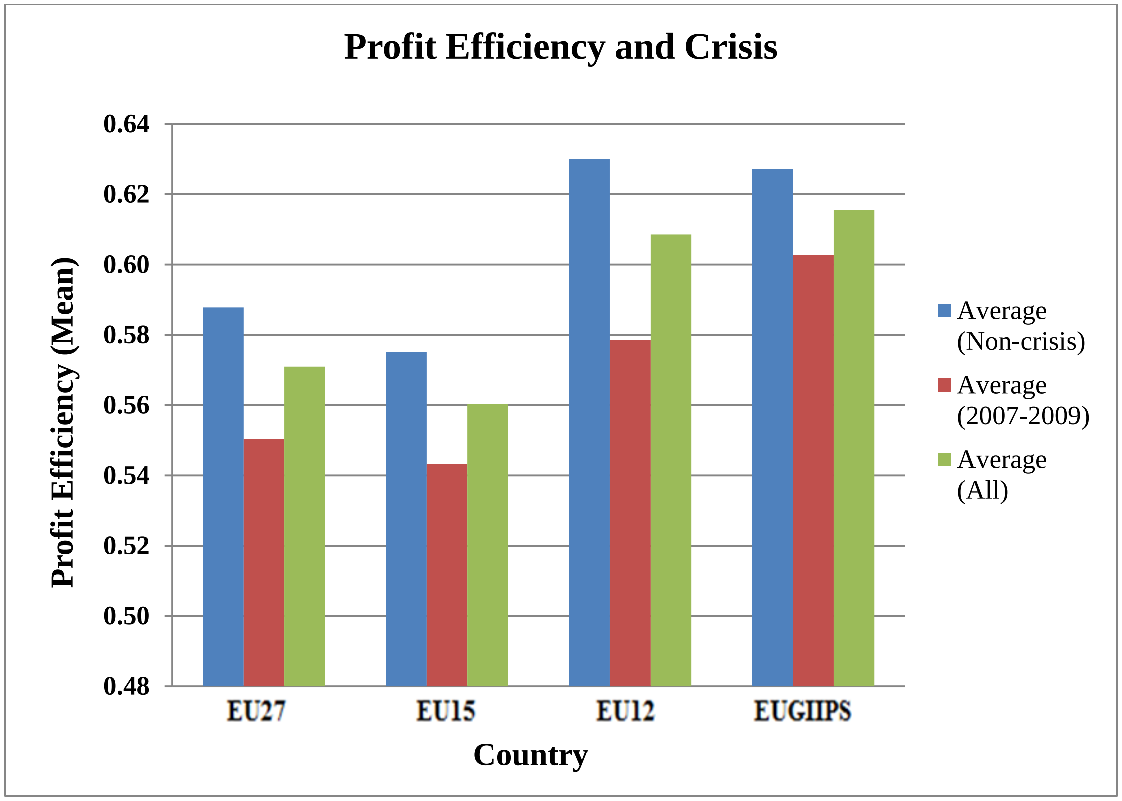

Figure 5.6. Bank Profit Efficiency and the Financial Crisis

5.7 Summary and Conclusion

This chapter provides an empirical analysis of the levels of cost and profit efficiencies of the European Union banking system over the period from 2004 until 2010. The results with regard to cost and profit efficiency estimates are presented according to four frontiers; the common frontier for the entire EU region and the separate frontiers constructed for the old and new EU countries as well as the GIIPS countries.

Regarding cost efficiency and using the common frontier for the purpose of comparison, we find that commercial banks in the GIIPS countries have the highest cost efficiency average over the study time period (2004-2010), while the new EU countries experience the lowest level of mean cost efficiency. Thus, the old EU countries' banking systems are, on average, more cost efficient than banking systems in the new EU countries. Based on size groups, large banks appear to be the most cost efficient banks while the very large banks are the least efficient. There is a positive evolution in the average cost efficiency levels for all the four EU sub-samples and a decrease in the efficiency gap between the old and the new EU countries over time. In addition, the results do not reveal a significant increase in the dispersion of cost efficiency in any of the four country groups over the period 2004-2010; however, all the EU groups experience a slight increase in efficiency dispersion after 2007 except for the new EU members. We also find that there is a decrease in the average cost efficiency level during the crisis time compared to its level during the non-crisis time for all the EU country groups, with the exception of the new EU countries.

As to profit efficiency and based on the common frontier, commercial banks in the GIIPS countries appear to be the most profit efficient banks, on average, in the sample. Also, and contrary to cost efficiency, the new EU member states appear to have more profit efficient banking systems than the old EU member states. Based on size groups, very large banks appear to be the most profit efficient banks while medium banks are the least efficient. Additionally, there is a positive evolution in the average profit efficiency levels for all the EU country groups and a decrease in the profit efficiency gap between the new and the old EU countries. The dispersion of bank profit efficiency does not show significant fluctuations over time in the case of the entire EU and the old EU countries, while it experiences clear fluctuations in the case of the new EU countries and the GIIPS countries. The world financial crisis is found to have a more obvious influence on profit efficiency than in the case of cost efficiency. The results show that the level of profit efficiency is lower during the crisis time than it is over the non-crisis time for all the EU country groups.

Chapter 6

Risk and Determinants of Efficiency in the European Union Banking Sector

6.1 Introduction

This chapter introduces an analysis for three types of bank risk; insolvency, liquidity and credit risks in the EU banking system. In addition, this chapter investigates the influence of these risk variables and other environmental variables on cost and profit inefficiencies. We focus on the aforementioned three types of risk because, as mentioned earlier in this thesis, we aim to investigate whether the level of these types of bank risk at the EU banks matter during the world financial crisis in terms of banking efficiency. In other words, we examine the role that these bank risks play during the crisis in the EU and to what extent maintaining lower level of these risks can protect European banks in times of financial distress with reference to banking performance. In addition, this chapter investigates the efficiency correlates, which would provide explanations for the variations in bank efficiency scores between banks and across countries. This investigation, as Berger and Mester (1997) argue, might have important implications for the public policy, research and bank management. This chapter addresses the second research question in this thesis.

Section 6.2 provides bank risk analysis concerning insolvency, credit and liquidity risks. Section 6.3 examines and discusses the determinants of bank cost and profit inefficiencies. And while Section 6.3.1 focuses on the effects of risk variables on bank inefficiency, Section 6.3.2 analyses the influence of other explanatory variables. Section 6.4 investigates the rank order correlation of efficiency scores and traditional non-frontier performance measures. Finally, Section 6.5 is the summary and conclusion.

6.2 Bank Risk Analysis

Before embarking on analysing the relationship between bank cost and profit efficiencies and bank risks, we start by analysing banking risks and this includes *insolvency risk*; measured by the ratio of equity to total assets, *liquidity risk*; measured by the ratio of total loans to total assets, and *credit risk*; measured by the ratio of non-performing loans to total gross loans. These three different bank risks are measured and analysed for the four EU samples used in this study. Descriptive statistics; mainly the mean value of the risk measures are used to analyse risk over the period 2004-2010 with the emphasis on the global crisis time (2007-2009). Tables 6.1 and 6.2 display the mean values of different bank risk measures along with the standard deviation and the number of observations for the four groups of the EU countries.

Table 6.1. Bank Risk Descriptive Statistics for the EU27 and the EUGIIPS

Year	Statistics	EU27			EUGIIPS		
		Insolvency Risk	**Credit Risk**	**Liquidity Risk**	**Insolvency Risk**	**Credit Risk**	**Liquidity Risk**
		Equity/TA %	NPL/TL %	TL/TA %	Equity/TA %	NPL/TL %	TL/TA %
2004	Obs	494	123	494	32	15	32
	Mean	*9.292*	*4.320*	*47.696*	*9.334*	*2.113*	*54.588*
	Std.Dev	6.805	5.762	24.607	7.388	1.931	22.008
2005	Obs	639	211	639	135	73	135
	Mean	*8.871*	*3.804*	*50.803*	*9.237*	*3.341*	*59.561*
	Std.Dev	6.752	5.204	24.773	7.823	3.173	24.302
2006	Obs	632	272	632	128	109	128
	Mean	*8.992*	*3.700*	*51.277*	*9.597*	*3.821*	*60.024*
	Std.Dev	7.752	5.091	25.651	8.998	4.619	25.089
2007	Obs	661	324	661	128	104	128
	Mean	*8.828*	*4.011*	*52.937*	*9.495*	*3.672*	*62.856*
	Std.Dev	6.941	6.202	25.723	7.643	4.762	24.848
2008	Obs	685	389	685	136	123	136
	Mean	*8.311*	*4.567*	*52.864*	*8.449*	*4.511*	*60.707*
	Std.Dev	6.329	5.551	26.366	5.859	5.557	25.606
2009	Obs	643	368	643	133	114	133
	Mean	*8.985*	*7.713*	*53.540*	*9.497*	*7.117*	*61.535*
	Std.Dev	7.077	9.509	24.997	8.730	7.559	24.086
2010	Obs	496	307	496	105	98	105
	Mean	*9.264*	*8.540*	*54.078*	*9.786*	*8.574*	*63.959*
	Std.Dev	7.436	8.819	24.303	8.830	8.646	23.404

Author’s calculations.

Table 6.2. Bank Risk Descriptive Statistics for the EU15 and the EU12							
		EU15			EU12		
Year	Statistics	Insolvency Risk	Credit Risk	Liquidity Risk	Insolvency Risk	Credit Risk	Liquidity Risk
		Equity/TA %	NPL/TL %	TL/TA %	Equity/TA %	NPL/TL %	TL/TA %
2004	Obs	373	81	373	121	42	121
	Mean	*8.719*	*3.795*	*47.525*	*11.057*	*5.332*	*48.223*
	Std.Dev	6.652	5.451	26.354	6.993	6.261	18.283
2005	Obs	504	154	504	135	57	135
	Mean	*8.596*	*3.315*	*50.709*	*9.898*	*5.125*	*51.155*
	Std.Dev	7.020	4.193	26.377	5.541	7.147	17.612
2006	Obs	504	203	504	128	69	128
	Mean	*8.871*	*3.329*	*50.322*	*9.466*	*4.792*	*55.039*
	Std.Dev	8.366	4.022	27.187	4.593	7.323	17.989
2007	Obs	517	229	517	144	95	144
	Mean	*8.612*	*3.374*	*51.686*	*9.607*	*5.545*	*57.428*
	Std.Dev	7.353	4.471	27.374	5.148	8.961	17.999
2008	Obs	538	273	538	147	116	147
	Mean	*7.887*	*3.991*	*50.734*	*9.859*	*5.924*	*60.659*
	Std.Dev	6.034	4.669	27.728	7.119	7.054	18.740
2009	Obs	501	257	501	142	111	142
	Mean	*8.639*	*6.104*	*51.980*	*10.206*	*11.439*	*59.044*
	Std.Dev	7.175	8.219	26.547	6.604	11.153	17.519
2010	Obs	385	216	385	111	91	111
	Mean	*8.940*	*6.744*	*52.919*	*10.390*	*12.804*	*58.097*
	Std.Dev	7.775	7.349	25.751	6.012	10.455	17.943

Author's calculations.

- **Equity Ratio (Insolvency Risk)**

Although the equity to total assets ratio was included in the efficiency functions for the reasons explained earlier, we include it again in this regression to examine its effect on cost and profit inefficiencies. In this sense, we avoid including this ratio twice in our analysis as we regress capital ratio against inefficiency here rather than efficiency following Kasman and Yildirim (2006). Table 6.1 shows how the level of insolvency risk changes over the study period for the entire EU region including its 27 member states and for the five EU GIIPS countries. The equity ratio mean of the EU27 region at the beginning of the period in 2004 (9.29%) is very close to its level at the end of the period in 2010 (9.26%); however, the ratio starts to decline from 2006 onward and significantly during the first half of the global crisis to reach 8.31% in 2008 before it starts to rise again. The equity ratio maintained by banks in the GIIPS countries is, to some extent, stable over the first four years before it drops considerably by more than 1% (from 9.50% in 2007 to 8.45% in 2008) and rises to 9.79% in 2010. From Table 6.2 similar results can be obtained for the old EU states where banks equity ratio declines significantly from 8.61% in 2007 to 7.89% in 2008; the year in which the global crisis strikes strongly the global financial system. Finally, and contrary to the old EU countries, the mean equity ratio of banks in the new EU states drops from 11.06% in 2004 to 9.90% in 2005, however, it starts to rise steadily from 2006 until 2010 to reach 10.39%. The overall standard deviation of the equity to assets ratio for the entire EU region ranges between 6.33% in 2008 and 7.75% in 2006.

Figure 6.1 below shows the time trend of the equity to total assets ratio (insolvency risk), which shows the level of risk for the four EU groups and allows comparing the level of insolvency risk maintained by commercial banks in the old and the new EU countries. It can be clearly seen from the graph that banks in the new EU countries maintain, on average, lower level of insolvency risk over time than the old EU countries, with no evidence of an increase in this risk during the crisis time. Also, the graph shows how the trend of capital ratio for banks in the old EU countries slightly declines between 2006 and 2007 while it sharply falls between 2007 and 2008 in parallel with the crisis event and the losses associated with it on the assets side. The overall banking system in the entire EU region witnesses a clear increase in insolvency risk in 2008; such increase starts from 2006 and becomes more obvious between 2007 and 2008. This analysis of equity ratio stands in line with the discussion of Blundell-Wignall and Atkinson (2009) and Carmassi *et al*. (2009) referring to the idea that banks in Europe increased their leverage before and by the time of the global crisis, while they started deleveraging as a result of the crisis, as the GAO (2010) argues.

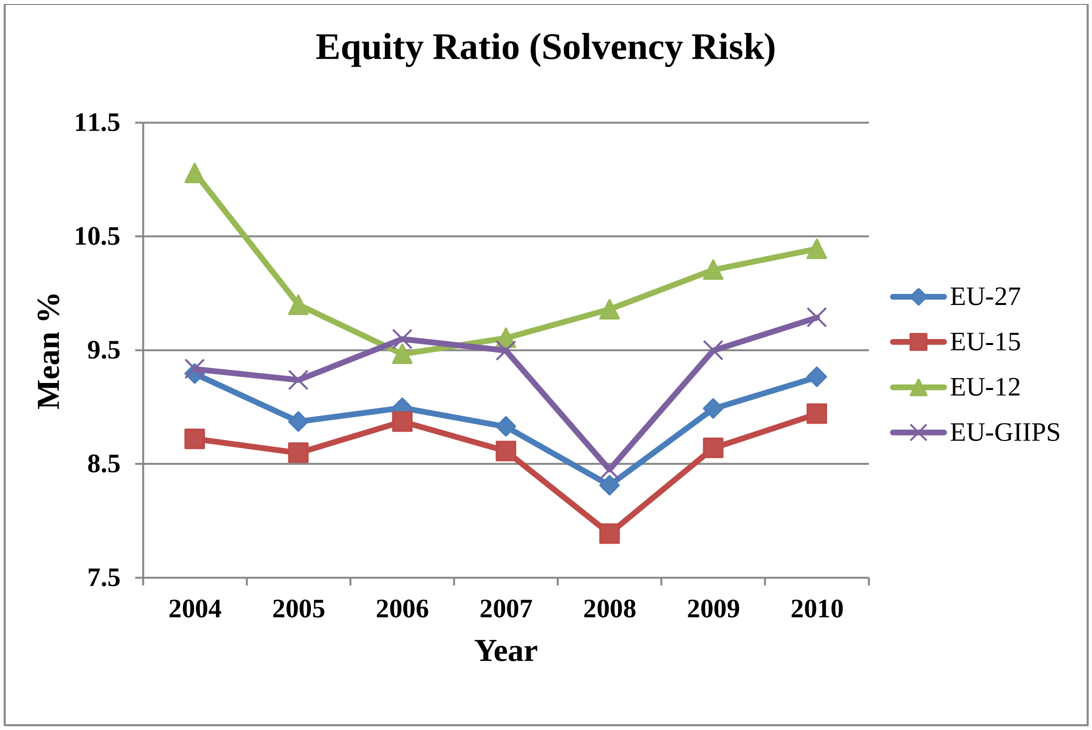

Figure 6.1. Equity to Total Assets Ratio (Insolvency Risk)

- **Total Loans/Total Assets (Liquidity Risk)**

Liquidity risk is measured by the ratio of total loans to total assets, where the mean values of such ratio are summarised for the four samples used in Tables 6.1 and 6.2. The mean value of total loans to total assets ratio increases significantly at the beginning of the period in 2004 (47.70%) to reach 50.80% in 2005 and 51.28% in 2006; however, there is no significant change during the time of the crisis in the EU27 sample. Banks in the GIIPS countries maintain high levels of total loans to total assets ratio over the study period at 54.59% in 2004 and 63.96% in 2010. Before the crisis, the mean ratio increases from 60.02% in 2006 to 62.86% in 2007, however, during the crisis time this ratio decreases by more than 2% (from 62.86% to 60.71%) between 2007 and 2008, while it increases again to reach 61.56% in 2009 and 63.96% in 2010. Table 6.2 shows that, concerning the old EU states, banks increase their liquidity risk ratio from 47.53% in 2004 to 51.69% in 2007, before it falls in 2008 (50.73%) and increases again in 2009 and 2010. Finally, the loan to assets ratio increases dramatically from 48.22% in 2004 to 60.66% in 2008, before it declines and reaches 58.10% in 2010. This means that banks in the new EU countries maintain higher levels of liquidity risk than their counterparts in the old EU countries over the seven years under study. The standard deviation of total loans to total assets ranges between 24.30% in 2010 and 26.37% in 2008 for the entire EU region for the ratio.

Figure 6.2 below produces a clear image of how the mean trends of liquidity risk for the four EU samples behave over the period 2004-2010. The figure shows that banks in the new EU states maintain higher levels of liquidity risk than banks in the old EU states over the seven-year period of time. Moreover, the trend of the EU27 sample goes up at the beginning of the period before it declines in 2008 and rises up again onward. Furthermore, banks in the four European samples increase their liquidity risk prior to the financial crisis (before 2007) which stands in line with the discussion of Brunnermeier (2009) and Diamond and Rejan (2009) with regard to the causes of the world crisis 2007-2009. However, the decrease in the ratio of total loans to total assets during the crisis, particularly in 2008 for the old EU countries, can be attributed to the difficulties of lending and issuing loans during the economic downturn and to deleveraging and selling off loans at banks in those countries.

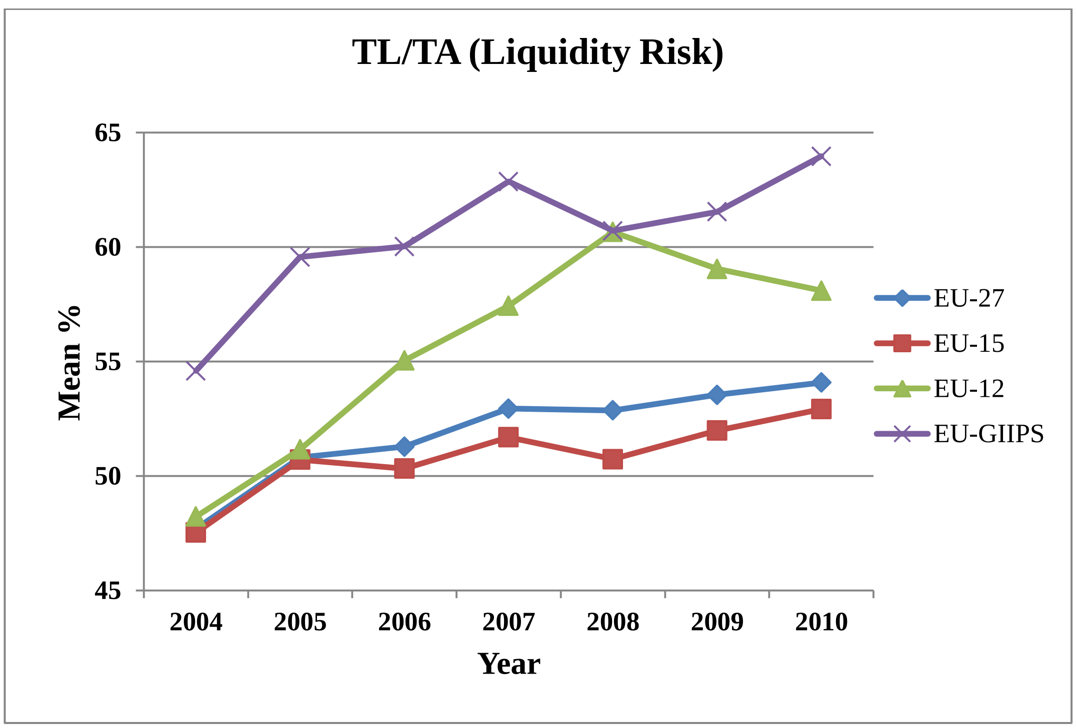

Figure 6.2. Total Loans to Total Assets Ratio (Liquidity Risk)

- **Non-Performing Loans/Gross Loans (Credit Risk)**

Table 6.1 shows that the mean of the non-performing loans to total loans ratio approximately doubles between 2004 (4.32%) and 2010 (8.54%) in the banking system of the entire EU area. The mean ratio increases significantly during the time of the crisis where it jumps from 4.01% in 2007 to reach 7.71% in 2009, reaching 8.54% in 2010. Regarding the GIIPS countries, the mean of credit risk increases by almost fourfold between 2004 (2.11%) and 2010 (8.57%), experiencing large increase over the crisis time 2007-2009. Similar results in Table 6.2 can be derived for banks in the old and new EU states where the mean of the non-performing loans ratio doubles over the period 2004 to 2010 and increases significantly during the crisis time. However, the increase in the mean value is very large in the new EU countries over the period 2007-2010 (from 5.55% to 12.80%) compared with 3.37% in 2007 and 6.74% in 2010 for banks in the old EU countries. The overall all standard deviation of the ratio of non-performing loans to total loans ranges between 5.09% in 2006 and 9.51% in 2009.

Figure 6.3 below shows homogenous time trends regarding credit risk that increases from 2007 onward for all the EU groups. However, the graph reveals that the overall banking system of the new EU states is, on average, riskier than the banking systems in the old EU states and faces a much steeper increase in credit risk from 2008 to 2010. It is crucial here to refer to the significant increase in the credit risk during and after the global crisis (from 2007 to 2010). That significant increase can be attributed to the tough global crisis conditions and the economic recession it caused, which might have revealed increases in the non-performing loans ratio and credit default between 2008 and 2010. That might also have been exacerbated by the European sovereign debt crisis from late 2009 onward.

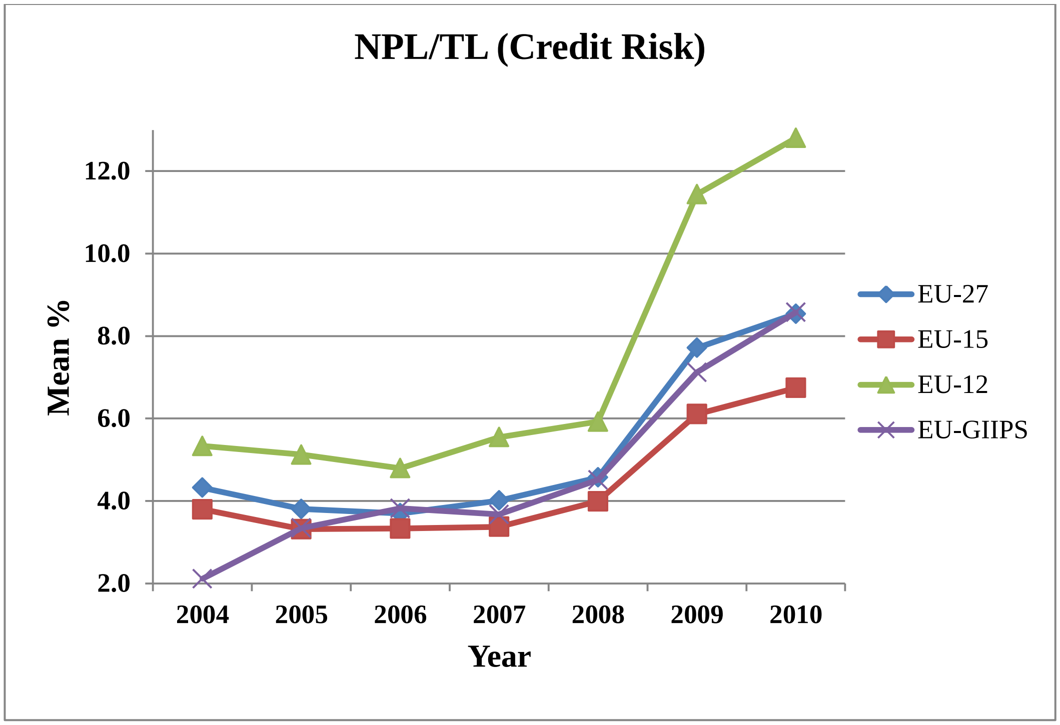

Figure 6.3. Non-Performing Loans to Total Loans Ratio (Credit Risk)

6.3 Risk and Determinants of Bank Inefficiency (Environmental Variables)

In order to investigate possible determinants of bank cost and profit inefficiencies, bank inefficiency is regressed on a set of bank risk variables and other independent variables. This investigation would provide explanations for the variations in cost and profit efficiency scores between banking systems in the European Union countries. As explained in the methodology section, the regression is implemented through the one-step Battese and Coelli (1995) estimation model. According to this model, bank inefficiency can be expressed as a function of a set of environmental variables that might contribute to different efficiency estimation scores.

For the purpose of this study, the environmental variables are divided into two main groups, risk variables and other explanatory variables. While risk variables include insolvency risk, liquidity risk, and credit risk, the other explanatory variables, on the other hand, include a set of bank-specific, industry-specific, and macroeconomic variables; among them is the world financial crisis (2007-2009). As has been done above for the analysis of bank efficiency levels, we present the inefficiency regression analysis according to four models. Model 1 contains the regression results based on a common efficiency frontier (EU27), while models 2, 3, 4 provide the regression results based on separate frontiers for the other three groups EU15, EU12, and EUGIIPS, respectively.

Tables 6.3 and 6.4 below summarise results of the regression analysis for cost inefficiency and profit inefficiency as dependent variables, respectively. It is important to note that separate regression is implemented when regressing inefficiency on the independent variable the non-performing loans to gross loans ratio. This is because due to data availability with regard to this variable we only include observations for which data on this variable is available, meaning that observations for 528 out of total 947 EU commercial banks are included in this regression. However, for the purpose of the comparison between the common frontier and separate frontiers of the EU country groups, we report results for this variable in the same column together with the other explanatory variables. Two correlation matrices are implemented to test the strength of the correlation between the environmental variables and we report the two matrices in Appendix 4a and Appendix 4b. As can be seen from the two matrices tables, no high correlation numbers are obtained between two environmental variables, meaning the problem of multicollinearity does not exist in our regression. We first start by investigating the effects of risk variables on bank cost and profit inefficiencies, and then we test the influence of the other environmental variables on inefficiency.

Table 6.3 Determinants of Cost Inefficiency

Variables	Parameters	Common Frontier	Separate Frontier		
		Model 1 (EU27)	**Model 2 (EU15)**	**Model 3 (EU12)**	**Model 4 (EUGIIPS)**
Bank-Risk Variables					
EQ	λ_1	0.0031*** (0.0005)	0.0029*** (0.0006)	-0.0012** (0.0054)	0.0008 (0.0023)
EQ_CRISIS	λ_2	-0.0009** (0.0005)	-0.0007** (0.0005)	-0.0004** (0.0058)	-0.0001 (0.0010)
TLTA	λ_3	-0.0263*** (0.0005)	-0.0284*** (0.0005)	-0.0214*** (0.0017)	-0.0329*** (0.0019)
TLTA_CRISIS	λ_4	-0.0023** (0.0007)	-0.0003** (0.0002)	-0.0011* (0.0016)	-0.0013** (0.001)
NPLTL	λ_5	0.0015** (0.0013)	0.00453*** (0.0016)	0.0028* (0.0042)	0.0037** (0.0095)
NPLTL_CRISIS	λ_6	0.0037** (0.0014)	0.0032** (0.0026)	0.0005* (0.0056)	-0.0012* (0.0048)
Other Explanatory Variables					
SIZE	λ_7	-0.0257*** (0.0074)	-0.0282*** (0.0082)	-0.0415* (0.0381)	-0.0597* (0.0324)
ROAA	λ_8	-0.0121*** (0.0014)	-0.0128*** (0.0017)	-0.0278*** (0.00686)	-0.0095* (0.0062)
INTERMED	λ_9	0.0002 (0.0001)	0.00086** (0.00002)	0.0008** (0.0002)	-0.0002 (0.0003)
CONC	λ_{10}	-0.0005 (0.0006)	0.0005** (0.0017)	0.0012 (0.0046)	-0.0048 (0.0035)
INFL	λ_{11}	-0.0077*** (0.0019)	-0.0128*** (0.0036)	-0.0028*** (0.0058)	-0.0137 (0.0099)
NIR	λ_{12}	-0.0021* (0.0030)	-0.0211** (0.0047)	0.0103* (0.0054)	0.0517* (0.0274)
CRISIS	λ_{13}	0.0342** (0.0099)	0.7493* (0.0921)	-0.1266* (0.1150)	0.0423** (0.0406)
C_DUMMY	λ_{14}	-0.0860* (0.0946)	…..	…..	…..
C_CRISIS	λ_{15}	0.0880* (0.072)	…..	…..	…..
GIIPS	λ_{16}	-0.1812*** (0.0652)	-0.1316** (0.0721)	…..	…..
GIIPS_CRISIS	λ_{17}	-0.0519 (0.0158)	-0.0466 (0.0164)	…..	…..

Note: ***, ** and * indicate 1%, 5% and 10% significance levels, respectively, and asymptotic standard errors in parentheses. EQ is equity ratio, EQ_CRISIS is equity and crisis interactive variable, TLTA is total loans to total assets ratio, TLTA_CRISIS is total loans ratio and crisis interactive variable, NPLTL is non-performing loans to total loans ratio, NPLTL_CRISIS is non-performing loans ratio and crisis interactive variable, SIZE is bank size, ROAA is return on average assets, INTERMED is intermediation ratio, CONC is market concentration, INFL is inflation, NIR is nominal interest rate, CRISIS is the world financial crisis 2007-2009, C_DUMMY is old countries dummy variable, C_CRISIS is old countries and crisis interactive variable, GIIPS is GIIPS countries dummy variable, and GIIPS_CRISIS is GIIPS and crisis interactive variable.

Table 6.4 Determinants of Profit Inefficiency

Variables	Parameters	Common Frontier	Separate Frontier		
		Model 1 (EU27)	**Model 2 (EU15)**	**Model 3 (EU12)**	**Model 4 (EUGIIPS)**
Bank-Risk Variables					
EQ	λ_1	0.0096*** (0.0009)	0.0114*** (0.0011)	0.0192*** (0.0054)	0.0141** (0.0055)
EQ_CRISIS	λ_2	-0.0029*** (0.0009)	-0.0021** (0.0011)	-0.0159*** (0.0075)	-0.0135** (0.0051)
TLTA	λ_3	-0.0072*** (0.0006)	-0.0090*** (0.0006)	-0.0138*** (0.0053)	-0.0128*** (0.0031)
TLTA_CRISIS	λ_4	0.0013*** (0.0004)	0.0014*** (0.0004)	0.0014*** (0.0015)	0.0034* (0.0024)
NPLTL	λ_5	0.0117*** (0.0117)	0.0144*** (0.0031)	0.0047** (0.0027)	0.0181** (0.0022)
NPLTL_CRISIS	λ_6	0.0066* (0.0024)	0.0042* (0.0031)	0.0029 (0.0041)	0.0022 (0.0065)
Other Explanatory Variables					
SIZE	λ_7	-0.0740*** (0.0116)	-0.0745** (0.0143)	-0.1099** (0.0375)	0.0123 (0.0719)
ROAA	λ_8	-0.0158*** (0.0013)	-0.0152*** (0.0018)	-0.0246*** (0.0031)	-0.0575*** (0.0094)
INTERMED	λ_9	-0.0001** (0.00007)	0.0003* (0.00003)	-0.0013** (0.0003)	0.0005 (0.0005)
CONC	λ_{10}	-0.0024** (0.0009)	-0.0019** (0.0011)	-0.0076** (0.0033)	-0.0087 (0.0055)
INFL	λ_{11}	0.0097*** (0.0039)	0.0167*** (0.0063)	0.0099*** (0.0054)	0.0042*** (0.0192)
NIR	λ_{12}	0.0220*** (0.0036)	0.0664** (0.0117)	0.0139*** (0.0043)	0.0774 (0.0471)
CRISIS	λ_{13}	0.3057** (0.1369)	0.0507** (0.0256)	0.0239** (0.0926)	0.1495** (0.1257)
C_DUMMY	λ_{14}	0.2824*** (0.0987)	…..	…..	…..
C_CRISIS	λ_{15}	0.0468 (0.0361)	…..	…..	…..
GIIPS	λ_{16}	-0.0865 (0.0880)	-0.0995* (0.0027)	…..	…..
GIIPS_CRISIS	λ_{17}	-0.0221 (0.0334)	-0.0132 (0.0351)	…..	…..

Note: ***, ** and * indicate 1%, 5% and 10% significance levels, respectively, and asymptotic standard errors in parentheses. EQ is equity ratio, EQ_CRISIS is equity and crisis interactive variable, TLTA is total loans to total assets ratio, TLTA_CRISIS is total loans ratio and crisis interactive variable, NPLTL is non-performing loans to total loans ratio, NPLTL_CRISIS is non-performing loans ratio and crisis interactive variable, SIZE is bank size, ROAA is return on average assets, INTERMED is intermediation ratio, CONC is market concentration, INFL is inflation, NIR is nominal interest rate, CRISIS is the world financial crisis 2007-2009, C_DUMMY is old countries dummy variable, C_CRISIS is old countries and crisis interactive variable, GIIPS is GIIPS countries dummy variable, and GIIPS_CRISIS is GIIPS and crisis interactive variable.

6.3.1 Bank Risk Effects on Inefficiency

We use equity to assets ratio, total loans to total assets ratio, and non-performing loans to total gross loans ratio to measure the effects of insolvency risk, liquidity risk, and credit risk on bank cost and profit inefficiencies. Moreover, we investigate the effect of these risks on inefficiency during the crisis time by interacting the aforementioned variables with the world financial crisis dummy variable, as explained earlier in this study. The purpose of investigating the effects of such interactive variables on bank inefficiency is to find out whether commercial banks with lower levels of risk better withstand the world financial crisis in the EU; Or to put it another way, we examine to what extent the level of risk affects the performance of EU banks during the crisis period. We start with insolvency risk, and then we move to liquidity risk and credit risk thereafter.

- **Equity Ratio (Insolvency Risk)**

The first risk variable to be investigated with regard to its effect on bank inefficiency is the capital ratio that represents insolvency risk. With regard to cost inefficiency, Table 6.3 shows that the coefficient of equity ratio has a negative sign in Model 3 (the new EU states) only, while it appears to be positive in the other three models. According to the common frontier of the entire EU region (Model 1), equity ratio has a positive and highly significant effect on cost inefficiency, meaning that less capitalised commercial banks are more cost efficient than well capitalised banks over the seven years under study. Similar results are shown for the separate frontier of the old EU states (Model 2) where the effect of this variable is positive and highly significant on cost inefficiency. The inverse relationship between bank cost efficiency and equity capital might be attributed to the idea that debt financing is cheaper than raising equity capital, hence more leveraged commercial banks appear to be more cost efficient than more capitalised banks. This reverse relationship between equity ratio and bank efficiency stands in line with the results obtained by Altunbas *et al*. (2007), by Allen and Rai (1996) and by Sun and Change (2011). On the other hand, equity ratio positively affects bank efficiency in the new EU states (EU12), meaning that well-capitalised banks in the new EU countries are more cost efficient than their counterparts with less equity capital. It can be said that as capital is more expensive than debt, this imposes pressure on banks in the new EU countries to reduce their operating costs. This stands in line with the result obtained by Fries and Taci (2005) and Yildirim and Philippatos (2007).

Regarding profit inefficiency, equity ratio has a positive and significant influence on profit inefficiency in all models, meaning that well-capitalised commercial banks are more profit inefficient that their counterparts in the European Union. This is because equity capital is more expensive than debts, which therefore increase bank costs associated with issuing equities and decrease bank profits. Also, this result complies with the moral hazard hypothesis that a bank with solvency problems would undertake risky business and invest in profitable activities, which therefore lead the bank to appear efficient in the short-term while paying for the consequence of its risky assets in the long-term. Similar results are obtained by Hasan and Marton (2003) who find positive impact of equity ratio on profit inefficiency in the Hungarian banking system.

- **Equity Ratio * Crisis**

Concerning the effect of equity ratio on cost inefficiency during the crisis time, Table 6.3 shows how, overall, the sign of equity ratio coefficient shifts from positive to negative over the crisis time in all models, meaning that the interactive variable of equity ratio and the crisis dummy negatively affect cost inefficiency. This supports our hypothesis that commercial banks in the EU with higher level of capital (lower insolvency risk) appear more cost efficient and less affected by the crisis than banks with higher leverage ratio. That is because such banks might have been able to borrow at cheaper prices as they are considered safer and sounder in such severe downturn and credit crunch time. The coefficient of this interactive variable is negative and significant (at 5 %) in all models except for Model 4 (the GIIPS countries) where it is insignificant.

Concerning bank profit inefficiency, the results are similar to those in the case of cost inefficiency, as can be seen from Table 6.4. The coefficient sign of equity ratio becomes negative and significant after interacting it with the world crisis dummy in all the four models, meaning that the capital ratio negatively and significantly affects profit inefficiency in the EU banking system during the crisis time. Again, this stands in line with our expectations as banks with higher capital might have faced lower costs with regard to borrowing compared to those with lower capital (riskier). So it can be concluded here that commercial banks with higher levels of capital (lower level of leverage) outperform their counterparts in terms of cost and profit efficiencies during the crisis time. In other words, well-capitalised commercial banks (with less insolvency risk) were able to better withstand the world financial crisis than less capitalised banks in the European Union.

- **Total Loans/Total Assets (Liquidity Risk)**

The second risk variable whose effect on bank efficiency is to be examined in this study is the ratio of total net loans to total assets as a proxy liquidity risk. Table 6.3 reveals a negative and highly significant relationship between the ratio of total loans to total assets and bank cost inefficiency, meaning that lower liquidity position (larger amount of loans) is positively connected with cost efficiency, which is not our expected sign. This inverse association between cost inefficiency and the amount of loans holds for the four models, meaning that more aggressive commercial banks (engaged in more lending activities) in the EU are more cost efficient. In other words, commercial banks that operate more efficiently in terms of costs are more successful and have better capability to expand their loans business in the EU market. Although we expected a reverse relationship between this variable and cost inefficiency, a similar result is obtained by Altunbas *et al*. (2007), Yildirim and Philippatos (2007), Allen and Rai (1996), and Maudos *et al*. (2002a).

With regard to profit inefficiency, as we expected, a negative and highly significant relationship between the ratio of loans to total assets and profit inefficiency is confirmed in all the four models. This means that commercial banks with higher liquidity risk (higher level of loans) operate more profit efficiently than banks with lower loans to assets ratio in the EU market. This stands in line with the idea that higher profits are consistent with more risky position, or with the conventional concept of the trade-off between liquidity and profitability, as higher liquidity level leads to lower profitability due to the opportunity costs accompanied with maintaining a high level of liquidity. Moreover, it might be attributed to the idea that, as Berger and Mester (1997: 39) argue, “banks’ loan products are more highly valued than securities, or it could reflect higher market power that exists in loan markets compared to the other product markets in which banks operate."

- **Total Loans/Total Assets * Crisis**

As to cost inefficiency, Table 6.3 again reveals a negative relationship between the ratio of total net loans to total assets multiplied by the crisis dummy and bank cost inefficiency in all the four models, which is again not our expected sign. These results mean that banks with higher loans to assets ratio are more cost efficient than their counterparts during the crisis time (2007-2009) as they are in the non-crisis time. Put it differently, commercial banks that operate more cost efficiently during the crisis period are more successful to expand their loan business in the EU markets.

On the other hand, the effect of the world crisis on the relationship between liquidity risk and bank profit inefficiency is obvious as the sign of this relationship reverses into positive when the interactive variable of liquidity and crisis dummy is created. This relationship is positive and highly significant in all models except in Model 4. This outcome suggests that commercial banks with higher loans to assets ratios appear to be less profit efficient during the crisis time, meaning that banks with more liquidity (less loans) over the financial crisis outperform their counterparts in reference to profit efficiency. That might be attributed to the loss associated with loan defaults over the crisis time and as Figure 6.3 in section 6.2 earlier shows, there is an increase in the percentage of non-performing loans during the period 2007-2009 which might have increased losses and decrease profitability as a consequence. Also, it might be attributed to the ability of more liquid banks to meet deposit withdrawals and other obligations without facing additional costs. Therefore, it can be concluded here that commercial banks with smaller amount of loans relative to total assets (more liquid banks) outperform their counterparts in terms of profit efficiency during the crisis time, though these banks fail to outperform less liquid banks in terms of cost efficiency. In other words, banks with less liquidity risk could withstand better the world crisis than less liquid banks in reference to profit maximisation but not in reference to costs minimisation.

- **Non-Performing Loans/Gross Loans (Credit Risk)**

The third risk variable to be investigated in this study is credit risk that is represented here by the ratio of non-performing loans to total loans. As can be seen from Table 6.3, there is a positive and significant effect of the ratio of non-performing loans (bad loans) to total loans on cost inefficiency in all four models. This suggests that commercial banks with higher amounts of bad loans are the least cost efficient banks in the EU, particularly in the old EU member states. This result is consistent with our expectations that the increase in the amount of non-performing loans would raise expenses related to handling such loans which in turn decreases bank cost efficiency. Therefore, it can be concluded from our result that commercial banks with higher cost efficiency are better at evaluating credit risk. This complies with the results obtained by Berger and De Young (1997), Fries and Taci (2005), and Altunbas *et al*. (2000).

Regarding bank profit inefficiency, Table 6.4 shows that this variable has a positive and significant influence on bank profit inefficiency, meaning that commercial banks with smaller amounts of bad loans are more profit efficient. These results stand in line with our expectations that non-performing loans increase the expenses associated with handling them and with the loan loss provision put aside to face the expected default of such loans, which in turn decrease bank profits.

- **Non-Performing Loans/Gross Loans * Crisis**

By the time of the world financial crisis, there was an increase in the credit risk held at the financial institutions in the US and the EU due to different factors. From Table 6.3, it can be shown that the interactive variable of credit risk and crisis dummy has a positive and significant (at 5%) effect on cost inefficiency in Model 1 (EU27). This stands in line with our expectations that higher amounts of non-performing loans during the crisis time would increase costs related to handling such bad loans, such as the expense related to screening, working out or selling off such bad loans. This means, again, that commercial banks maintaining less bad loans during the crisis time appear to be more cost efficient than their counterparts. However, in Model 4, in which a separate frontier is constructed for the GIIPS countries, the effect of this interactive variable on bank cost inefficiency is negative and significant (at 10%), which does not comply with our expectations. This means that banks with more bad loans in the GIIPS countries are more cost efficient than banks with less bad loans over the crisis time. This can be interpreted by the "cost skimping" hypothesis suggested by Berger and De Young (1997) which refers to a trade-off between short-term cost efficiency and future risk taking. Under this hypothesis, a bank appears to be more cost efficient as it devotes fewer resources to "screening loan customers, appraising collateral, and monitoring and controlling borrowers after loans are issued [which] makes the bank appear to be cost efficient in the short run" (p.853). Thus, the stock of non-performing loans remains unaffected in the short run, while this stock increases in the future, leading to increases in the expenses associated with dealing with these bad loans.

As to profit inefficiency, Table 6.4 shows that this interactive variable has the expected positive effect on profit inefficiency in all models; though the effect is significant only at 10% in Model 1. This means that a higher amount of non-performing loans has a positive but weak effect on profit inefficiency in the EU overall and in the old EU countries and a non-significant effect in the new and in the GIIPS EU countries during the crisis period. Consequently, it can be concluded here, in comparison with the studies that highlight the role of credit risk in the financial crisis, that commercial banks with lower amounts of non-performing loans (lower credit risk) outperform their peers in terms of cost efficiency, with the exception of banks in the GIIPS countries, and in terms of profit efficiency, particularly in the old EU states, during the financial crisis period.

6.3.2 Other Variables' Effects on Inefficiency

- **Size**

Further to the above discussion, we investigate whether bank-specific, industry-specific and macroeconomic variables can explain efficiency differences between countries and among banks. The first variable which belongs to the bank-specific category is bank size, measured as the logarithm of bank total assets. Concerning cost inefficiency, Table 6.3 above shows that banks size is negatively associated with bank cost inefficiency in all the four models, and it is highly significant (at 1%) in Model 1 and Model 2, while it is significant at 10 % in Model 3 and Model 4. This stands in line with our expectations that larger banks might have benefited from economies of scale and scope from growth and joint production, which increase efficiency. Also, larger banks might benefit from a better and more professional management team which is more able to control costs and increase revenues. This outcome is similar to that obtained by Hasan and Marton (2003), Yildirim and Philippatos (2007) and Matousek and Taci (2004).

Regarding profit inefficiency, it can be seen from Table 6.4 that there is a negative and significant effect of bank size on bank profit inefficiency in all models except in the case of Model 4 (EUGIIPS). For the groups of the entire EU region, the old EU countries, and the new EU countries larger commercial banks appear to operate more profit efficiently than smaller banks, again, probably due to the lower costs resulting probably from exploiting economies of scale and economies of scope, which complies with our expectations and results obtained by Yildirim and Philippatos (2007). Furthermore, it can be explained through the concept of too-big-to-fail, where larger banks invest in highly risky assets leading to higher profitability. On the other hand, in the GIIPS countries (Model 4), the size variable appears to have a positive influence on bank profit inefficiency, meaning that smaller banks are more efficient. This might be due to the fact that smaller banks in the GIIPS countries issue more risky loans or deal with small size customers in return for higher interest rates, the coefficient of this variable is insignificant though.

- **Return on Average Assets (ROAA)**

The second bank-specific variable to be investigated in the other explanatory variables category is the return on average assets. With regard to cost inefficiency, it can be concluded from Table 6.3 that the return on average assets has a negative effect on cost inefficiency in all the four models and this effect is highly significant at 1% in Models 1, 2 and 3, while it is significant at 10% in Model 4. This means that commercial banks with higher return on average assets appear to be more cost efficient than their counterparts with lower return on average assets ratio. This result is identical to the results obtained by Carbo *et al.* (2002) and Lensik *et al*. (2008).

As to profit inefficiency, Table 6.4 indicates a negative and highly significant effect of this variable on profit inefficiency for all the EU country groups (all models). This means that commercial banks with higher return on average assets ratios operate more efficiently in terms of profit than banks with lower return on average assets ratios. This stands in line with the belief that better utilisation of bank assets enhances bank profit efficiency, and this result resembles the result obtained by Chan and Abd Karim (2010). If the return on average assets can be seen as a performance measure, then it is not surprising that it is positively correlated with both cost and profit efficiencies.

- **Intermediation Ratio**

The third bank-specific variable to be investigated in this study is the intermediation ratio calculated by dividing total loans by total deposits. Table 6.3 shows that the expected negative effect of this variable on cost inefficiency is confirmed only in the GIIPS countries (Model 4) even though it is not significant. However, the intermediation variable is found to have a positive effect on cost inefficiency in Models 1, 2 and 3 while it is only significant in Model 1 and Model 2. Therefore, it can be concluded that banks with lower intermediation ratios operate more efficiently in terms of costs than their counterparts in the entire EU and new and old EU countries, while the reverse is true in the case of GIIPS countries. The positive relationship between cost inefficiency and the intermediation ratio might be attributed to the higher costs associated with converting deposits into loans, such as screening and creditworthiness evaluation costs, than converting deposits into other investments that might be associated with lower costs.

With regard to profit inefficiency, Table 6.4 also shows mixed results as this variable appears to have a negative and significant effect on profit inefficiency only in Model 1 (EU27) and Model 3 (EU12), while in Models 2 and 4 the effect is positive and significant at 10% only in Model 2. This means that banks with higher intermediation ratios are more profit efficient than their counterparts under the common frontier of the entire EU region and in the new EU countries, while this is not confirmed under the old EU states and the GIIPS countries separate frontiers.

- **Market Concentration**

An industry-specific variable whose effect on cost and profit inefficiencies is examined in this study is market concentration calculated as the sum of total assets of the five largest banks divided by the total assets of the entire banking system. Regarding cost inefficiency, the only significant (at 5%) influence this variable has is on cost inefficiency in Model 2 (EU15) and it is positive. This means that commercial banks in the old EU countries feel less pressure to control their costs in a concentrated environment so that they might spend more money on their stuff and other personnel expenses, which, in turn, might support the idea that concentration is a result of market power in these countries.

In terms of profit inefficiency, as we expected, the effect of market concentration on profit inefficiency is negative in all models while it is only significant in Models 1, 2, and 3 at 5% but not in Model 4, as can be seen from Table 6.4. This result suggests that commercial banks in more concentrated market (less competitive environment) have greater market power and hence they have better ability to increase their profits in the EU and therefore appear to be more profit efficient. In other words, commercial banks are proved to be more profit efficient when operating in less competitive market in the EU as a whole, in the old EU countries, and in the new EU countries on average but this result is not strong enough to be confirmed in the EU GIIPS countries.

- **Inflation Rate**

The first macroeconomic variable to be investigated with regard to its possible effect on bank cost and profit inefficiencies is inflation rate. Table 6.3 shows a negative influence by inflation rate on bank cost inefficiency in all four models, while the coefficient of this variable appears to be insignificant in Model 4 (EUGIIPS). This suggests that commercial banks operate more cost efficiently in an inflationary environment than in a deflationary environment in the EU region overall, while this result is less obvious in the GIIPS countries within the EU. This can be attributed to the belief that commercial banks in the EU have fairly good capability with regard to forecasting the changes in the inflation rate so as to take preparatory procedures to decrease costs associated with more inflationary markets.

On the other hand, Table 6.4 reveals entirely different outcomes concerning how inflation affects profit inefficiency. It can be seen from the table that the effect of inflation rate on bank profit efficiency is negative and highly significant (at 1%) in all four models, meaning that higher inflation increases profit inefficiencies of commercial banks in the EU area. This contradicts with what is concluded in the case of cost inefficiency as banks are said to be successful in forecasting the future inflation rate and handling their costs based on their successful forecasting. However, it can be argued here that even if commercial banks are successful in forecasting the future inflation rate, they might be more flexible in terms of decreasing the costs associated with inflationary environment than in terms of increasing their profit in the same environment. Also, it can be explained that banks fail to impose enough increase on their lending interest rate, probably to remain competitive, so as to offset a specific increase in inflation rate, and therefore decrease their profits. Furthermore, inflation overall plays the main role in decreasing the value of money, and thus higher inflation might decrease the value of money used by banks in different investments, leading to lower profitability.

- **Nominal Interest Rate**

The nominal interest rate is calculated as the long-term government bond yield. As can be seen from Table 6.3, the result is mixed with regard to the influence of nominal interest rate on bank cost inefficiency. While the effect is negative for the entire EU region (Model 1) and the old EU countries (Model 2), it is positive for the new EU countries and the GIIPS countries, and it is not highly significant in all four models. This indicates that our expected positive sign holds only in the case of the new EU states and the GIIPS countries where banks face increases in their costs with the rise in interest rate. In contrast, higher interest rate increases cost efficiency in the main model (entire EU) and the old EU member states possibly due to the better hedging strategy against interest rate movements followed by commercial banks in the old member states.

As to profit inefficiency, Table 6.4 reveals positive influence by interest rate on profit inefficiency in all models; this influence is insignificant in Model 4 (EUGIIPS) though. This suggests that commercial banks face contractions in their profits generated as the nominal interest rate rises according to all common and separate frontiers adopted in this study. This might be attributed to the belief that commercial banks in the EU have an excess of flexible-rate liabilities over flexible-rate assets or to the weak hedging strategies run by those banks with regard to generating profits.

- **World Financial Crisis (2007-2009)**

The US subprime crisis spilled over to the EU and became a world financial crisis as a result of the financial contagion through financial sector and trade linkages between the two regions. Starting with cost inefficiency, Table 6.3 shows that for the main model (Model 1) the variable of the crisis affects positively and significantly (at 5%) bank cost inefficiency, meaning that during the crisis time commercial banks face deterioration in their cost efficiency (increase in total costs) in the entire EU region, on average. A similar result is revealed in Model 2 (EU15) and Model 4 (EUGIIPS) where the effect of the crisis is also positive and significant, meaning that banks' cost efficiency decreases over the crisis time in the old EU members and the GIIPS countries, respectively. These results are not surprising as banks might encounter higher costs related to more expensive borrowing in a low liquid environment, to higher costs associated with raising capital (deleveraging), and to more expenses devoted to monitoring and evaluating creditworthiness of clients (expenses related to risk management). However, our expected sign does not hold in the case of the new EU member states (Model 3) where the crisis variable has a negative influence on cost inefficiency, meaning that banks in these countries manage to decrease their total costs over the crisis time. In other words, commercial banks in the new EU countries appear to be more efficient in terms of cost during the crisis years than in other years, the coefficient of this variable is only significant at 10% though.

With regard to profit inefficiency, the coefficient of the world financial crisis is positive in all the four models and significant at 5%. This means that the level of profit efficiency of commercial banks in the EU deteriorates over the crisis time, or in other words, banks in the EU appear to be more profit efficient in the non-crisis time over the period under study. This stands in line with our expectations that banks' profits decrease over the crisis period probably due to weaker investing and lending business associated with lower liquidity caused by deposits withdrawals and more difficult borrowing by banks. Moreover, losses associated with loan defaults and other assets and the increase in total costs at banks over the crisis time might also contribute to the deterioration in profit efficiency.

- **Country Dummy**

For the purpose of making a comparison between the efficiency levels of banking systems in the old and the new EU member states, we include in the regression a dummy variable for the old EU countries. This variable is only included in the main model (Model 1) where we pool all banks from all the 27 EU countries together and run the regression under a common frontier. As Table 6.3 shows, the effect of this variable on cost inefficiency is negative and significant at 10% which means that commercial banks in the old EU member states are, overall, more cost efficient than their counterparts in the new EU countries. This stands in line with our expectations that banks in the old EU countries operate in a more competitive environment that imposes pressure on them to reduce their costs in addition to better technology and management techniques that help them appear more cost efficient.

In contrast, Table 6.4 reveals a positive and highly significant effect of this variable on bank profit inefficiency meaning that banks operating in the new EU countries are more profit efficient than banks in the old EU countries. This, as explained earlier in this study, might be attributed to the belief that commercial banks probably operate in a less competitive environment in the new EU members, allowing them to make higher profits compared to banks in the old EU members where the level of competition in the market is much higher. These results with regard to the effect of country dummy variable on cost and profit inefficiencies support what we concluded in the bank efficiency analysis section earlier above, that a bank efficiency gap exists between the old and new EU countries. While this gap is in favour of the old EU countries in the case of cost efficiency, it is in favour of the new EU countries in the case of profit efficiency.

- **Country Dummy * Crisis**

As we use a large sample that consists of commercial banks operating in 27 EU member states, it is unlikely that the world crisis hit banking systems equally in those countries. For this reason we investigate, using this interactive variable, whether banking systems in the old and new EU countries, on average, react equally or differently to the world crisis in terms of efficiency. Table 6.3 indicates that, as expected, this variable has a positive and significant (at 10%) influence on bank cost inefficiency, meaning that the negative effect of the world crisis on cost efficiency is stronger in the case of the old EU countries compared to that in the case of new EU countries. This might be attributed to the idea that the old EU countries are more integrated with the US banking and financial system as well as the belief that financial institutions in those countries invested more in the US mortgage toxic securities and other related securities than those in the new EU countries. Therefore, financial contagion (through financial sector and trade linkages) played an important role for the stronger spread of the US crisis to the old EU member states than to the new EU states. For instance, Shirai (2009) argues that by the end of 2007, the UK, France and Germany were among the top five countries in which the United States had its largest cross-border stock investments, and the UK was the most active foreign investor in the US stocks. Moreover, UK, France and Germany were among the top five countries in which the United States held substantial amount of debt securities, while the UK was the third largest foreign investor in US debt securities. On the other hand, and as can be seen from Table 6.4, this interactive variable has no significant effect on profit inefficiency, meaning that there is no solid evidence that the crisis affects differently banking profit efficiency in the two groups.

- **GIIPS-Dummy**

We use this variable to investigate whether commercial banks operating in the GIIPS countries differ from other EU banks operating in the other EU member states in terms of their efficiency level. Unfortunately, as stated above, the Eurozone crisis that has its roots mainly in the GIIPS countries is still on-going after 2010 while we only have data till 2010. For this reason we have no specific expectations with regard to the effect of this variable on bank cost and profit inefficiencies. We include this variable in the main model (Model 1) and in Model 2.

As can be noticed from Table 6.3, the effect of the GIIPS dummy variable on cost inefficiency is negative and highly significant (at 1%) in the main model (Model 1), meaning that commercial banks in the GIIPS countries are more cost efficient than banks in the other 22 EU countries over the period under study. Similarly, in Model 2 the effect of this variable is negative and significant at 5%, suggesting that banks in the GIIPS countries are less cost inefficient than their counterparts in the other old EU member states. With regard to profit inefficiency, Table 6.4 shows that, again, this variable has a negative influence on profit inefficiency according to Model 1 and Model 2; however this influence is insignificant in the main model and only significant at 10% in Model 2. This suggests that there is no evidence that banks in the GIIPS countries operate more efficiently, overall, in terms of profit than banks in the other EU member states, whereas there is some evidence that banks in the GIIPS states outperform their peers in the old EU countries with regard to profit efficiency.

- **GIIPS -Dummy * Crisis**

We include this variable to find out whether the world financial crisis affects bank efficiency differently in the GIIPS countries and in the other EU member states, and we include this variable in Model 1 and Model 2. As can be seen from Table 6.3, the effect of this interactive variable on cost inefficiency is negative but insignificant in Model 1 and Model 2. With regard to profit inefficiency, this variable appears also to have a negative but insignificant effect on profit inefficiency in the two models, meaning that there is no solid evidence that banks in the GIIPS countries operate more cost or profit efficiently during the world crisis time than the other banks in the other EU member states.

6.4 Rank Order Correlation of Efficiency Scores and Traditional Non-Frontier Performance Measures

Bauer *et al*. (1998) argue that identifying the rough ordering of which banks are more efficient based on parametric and non-parametric approaches is more important than generating the efficiency scores because that would help the regulators decide whether a particular regulatory decision would be useful and effective in improving the efficiency of banks. In our study we only use the parametric approach; the stochastic frontier approach (SFA), to estimate bank cost and profit efficiencies of European Union commercial banks. For this reason, we adopt the Spearman rank order correlation technique to see whether similar rankings of banks can be obtained based on cost and profit efficiency scores generated using the stochastic frontier approach, and this technique is considered as an indicator of consistency by Bauer *et al*. (1998). Furthermore, we use the same technique to find out if the SFA (in terms of both cost and profit efficiencies) and standard financial ratios (non-frontier measures) can generate similar rankings of banks in our study. If similar results with regard to bank rankings can be generated from the two methods, then that would increase the confidence of the policy makers that the estimated efficiencies are accurate indicators of performance (Bauer *et al*., 1998).

The two frontier efficiency measures are the cost and profit efficiencies generated using the stochastic frontier approach, while four standard financial ratios that are popular measures of bank performance are used for the application of Spearman rank order correlation. These financial ratios are the return on average assets (ROAA); the total costs to total assets ratio (TC/TA); the equity to total assets ratio (EQ/TA); and the total loans to total deposits ratio (LOAN/DEPOSIT). The first ratio, return on average assets, is used to assess bank profitability with higher values mean more efficient use of bank assets. The second ratio, total costs to total assets ratio, is used as an indicator of economic optimisation with reference to banks' costs since it measures banks' costs relative to bank size. The third ratio, equity to total assets, is a measure of insolvency of financial risk with higher ratio implies less risky bank, as explained earlier in this study. Finally, the loans to deposits ratio, representing the intermediation ratio with higher values, refers to the higher ability of a bank to convert its deposits into loans.

Table 6.5 below summarises the pairwise Spearman rank order correlation coefficients between bank cost and profit efficiency scores, and between them and the standard financial ratios aforementioned. It can be seen from the table that the Spearman rank order correlation between cost and profit efficiencies are positive and significant at 1%, however, the correlation is fairly low and stands at 0.24. This means that the rankings of banks given by cost and profit efficiencies are somewhat consistent, suggesting that the most cost efficient banks are also the most profit efficient banks. Table 6.5 also shows that the rank correlation of the return on average assets and both cost and profit efficiency is positive and significant, suggesting that the most cost and profit efficient banks have the highest return on average assets ratio, the correlation is very low though. Moreover, and not surprisingly, total costs to total assets ratio appears to have a negative and highly significant rank order correlation with both cost and profit efficiencies, meaning that the most cost and profit efficient banks have the lowest costs to assets ratios. While the rank order correlation between costs to assets ratio and cost efficiency stands at (0.66), it is slightly lower between this ratio and profit efficiency (0.53). We also observe a positive and rank order correlation between equity ratio and cost and profit efficiencies, and this correlation is significant at 1% in the case of cost efficiency and at 5% in the case of profit efficiency. This might suggest that the most cost and profit efficient banks maintain the highest level of equity capital. Finally, we observe a negative and significant (at 5%) rank order correlation between the loans to deposits ratio and cost efficiency, suggesting that there is some evidence that the most cost efficient banks have the lowest intermediation ratio, and this correlation is fairly high at 0.56. On the other hand, this ratio has a positive and significant (at 10%) rank order correlation with profit efficiency, indicating that there is some weak evidence that the most profit efficient banks have the highest loans to deposits ratios and the correlation is fairly low at 0.33.

Table 6.5 Spearman's Rank Order Correlation of Efficiency and Traditional Performance Measures

	Cost*eff*	**Profit*eff***
Cost*eff*	1.0000	
Profit*eff*	0.2424***	1.0000
ROAA	0.0315**	0.0859***
TC/TA	-0.6577***	-0.5268***
EQ/TA	0.1052***	0.1091**
LOAN/DEPOSIT	-0.5592**	0.3340*

Notes: Cost*eff* = cost efficiency; Profit*eff* = profit efficiency; ROAA = return on average assets; TC/TA = total costs/ total assets; EQ/TA = equity/total assets. ***, ** and * indicate that correlation is significant at 1%, 5% and 10%, respectively.

6.5 Summary and Conclusion

This chapter presents a descriptive analysis for bank risks and investigates the determinants of cost and profit inefficiencies. The analysis shows that, overall, the new EU countries maintain the lowest level of insolvency risk (highest level of capital ratio), while the old EU countries have the highest level of insolvency risk over the seven years under study. Also, there is a clear increase in this risk before and during the world financial crisis period for all the EU groups except for the new EU members. However, in terms of credit risk, the new EU states appear to be the riskiest among the other country groups with the old EU countries being the least risky, and there is increase in this risk for all the groups by the crisis time. Concerning bank liquidity risk, the results conclude that the old EU countries are the least risky in the sample over time, with a clear increase in this risk for the new EU countries before the crisis time.

The determinants of cost and profit inefficiencies are investigated in the regression of the Battese and Coelli (1995) one-step model in this chapter and are divided into risk variables and other explanatory variables. We investigate the effects of the three risk variables aforementioned in addition to their effects on bank inefficiency during the crisis time. The results show that the capital ratio has, in general, a positive effect on both cost and profit inefficiencies, while this effect shifts to negative during the crisis, suggesting that better capitalised banks (with less insolvency risk) perform better over the crisis than less capitalised banks in terms of both cost and profit efficiencies. Loans to assets ratio (liquidity risk) affects negatively both cost and profit inefficiencies, while this effect turns to positive during the crisis time only in the case of profit inefficiency. This means that more liquid banks outperform their counterparts in terms of profit maximisation during the crisis. Furthermore, the ratio of non-performing loans to gross loans (credit risk) has a positive effect on cost and profit inefficiencies over the crisis and non-crisis time and this effect is more significant in the case of cost inefficiency than profit inefficiency over the crisis. This suggests that banks with lower credit risk appear to be more cost and profit efficient over stable and non-stable economic conditions. Therefore, it can be concluded here that the level of these bank risks matters during the crisis time and banks that maintain higher level of such risks appear less efficient over the financial crisis time in the

EU. The regression results, also, show that the financial crisis has a positive influence on cost and profit inefficiencies, meaning that commercial banks in the EU perform better in the non-crisis time. Finally, this chapter examines the Spearman rank order correlation of efficiency scores and conventional accounting based performance measures. We find that cost and profit efficiencies are significantly and positively correlated with each other meaning that most cost efficient banks are also most profit efficient banks, but the correlation is fairly low. Return on average assets, cost to assets ratio, equity to assets ratio and loans to deposits ratio are also, in general, significantly correlated with both cost and profit efficiencies.

Chapter 7

Bank Stock Performance, Efficiency and Risk in the EU Markets

7.1 Introduction

Over the past two decades, competitive pressures have progressively driven banks to focus on generating returns to shareholders. As a result, investigating the correlates of bank performance and its effect on stock prices has become increasingly important. Different studies on stock markets have found that stock prices incorporate publicly available information (Ball and Kothari, 1994). Sufian and Majid (2009) argue that operating efficiency measures should be considered in the price information processing in an efficient stock market as they represent publicly available information. In a semi-strong efficient stock market where most of the information is incorporated into stock prices, stock price performance is the best measure of whether a firm is creating value for shareholders or not (Brealey and Myers, 1991). Therefore, it might be expected that efficient banks perform better than inefficient banks and this will be reflected in stock prices directly through lower costs or higher profits, or indirectly through customer satisfaction which might improve stock prices performance (Sufian and Majid, 2009).

Different methods have been developed and used in the banking literature to investigate the relationship between stock performance and different factors, particularly risk. One of such methods is CAPM that was introduced by Sharpe (1964) and Lintner (1965) and was discussed in section 2.5.1 in this thesis. Stone (1974) developed a Two-Factor Model in which interest rate risk was added to the market risk as an extension to CAPM. Merton (1973), in turn, argued that an investor might also face other sources of risk, leading to the creation of the Multifactor CAPM model in which extra market sources of risk are considered. In addition, the Arbitrage Pricing Theory (APT) was developed by Ross (1976) and it postulates that market risk itself is made up of a number of separate systematic factors that should be taken into account. This theory criticises that the CAPM requires the investors' utility to be measured in terms of the expected return and risk as measured by the return standard deviation, also the market portfolio needs to include all assets in the economy where many of them are not empirically observable (Pilbeam, 2005). Fama and French (1992, 1993) have challenged the single factor CAPM and extended the model to account for other factors, and this defines what is called multi-factor models.

In this study, we adopt multi-factor models in which we examine the sensitivity of bank stock returns to different factors. Therefore, the main objective of this chapter is to investigate the factors that affect commercial banks' stock returns. In particular, this chapter investigates whether variations in cost and profit efficiencies and other risk variables explain variations in bank stock returns in the EU Markets. We use three bank-specific risk variables that we focused on in the previous chapter as well as market and interest rate risks. This allows us to see how sensitive bank stock returns are to changes in efficiency and risk variables. Therefore, this chapter addresses the third research question in this thesis.

This chapter is organised as follows. Section 7.2 surveys literature review on the relationship between bank efficiency and stock performance (section 7.2.1) and the relationship between risk and stock performance (section 7.2.2). Section 7.3 explains the methodology used to investigate the effects of different factors on bank stock returns. This includes a summary of fixed and random effects models for panel data and the diagnostic tests related as well as two regression model specifications adopted in this chapter. Also, this section defines the dataset and the dependent and independent variables included in the empirical analysis. Section 7.4 provides and reports the empirical results generated by the two regression models and the related analysis and discussion. Section 7.5 is summary and conclusion.

7.2 Literature Review

The aim of this section is to provide a summary of some studies that investigate the effect of bank efficiency and risk factors on the stock returns of banks and other financial institutions. We start by presenting some literature that examines the relationship between bank cost and/or profit efficiencies and the stock performance of banks, and then we briefly highlight some studies that examine the influence of different types of risk on stock returns.

7.2.1 Studies on Bank Efficiency and Stock Performance

There are a considerable amount of studies that investigate banking efficiency in Europe, as clarified in Chapter 3. However, as Beccalli *et al*. (2006) point out, studies that link bank efficiency and stock performance are scarce in general and in Europe specifically. Stock prices should reflect the performance of a firm; hence, higher profits and/or lower costs, which are indicators of a better firm performance, should give better expectations by shareholders regarding the financial future of their shares values. This in turn should be expected to result in higher stock prices in an efficient stock market as long as profits and costs are calculated using publicly known information (i.e. a firm's financial statements). In this section, we survey some of these studies that investigate such a relationship in different countries in the world; we start with European studies though.

Chu and Lim (1998) shed light on the linkage between bank efficiency and stock performance in Asia. The study estimates bank cost and profit efficiencies for six listed banks in Singapore using data envelopment analysis (DEA) over the period 1992-1996. Regarding cost efficiency, the results show that the average cost efficiency of the six banks over the period 1992-1996 stands at 95.3%, while the profit efficiency estimate is lower and stands at 82.6%. As to the relationship between share performance and bank efficiency, Chu and Lim (1998) find that the correlation coefficient between stock price changes and cost efficiency changes stands at 0.32 and is significant at 10%. On the other hand, the correlation coefficient between changes in stock prices and changes in profit efficiency is much higher and stands at 0.82. This means that changes in bank share prices reflect changes in bank profit efficiency rather than changes in cost efficiency.

Eisenbeis *et al*. (1999) examine the informativeness of the cost efficiency of 254 bank holding companies in the US using the SFA and linear programming frontier for the period 1986-1991. Furthermore, the authors investigate the relationship between bank cost inefficiency and bank stock returns along with other variables. The results show that inefficiency estimated using stochastic frontier is negatively and significantly related to bank stock returns. This means that stocks of efficient firms tend to outperform their less efficient counterparts. On the other hand, in the case of inefficiency estimated using programming frontier, the results show no significant correlation between bank efficiency and stock returns.

Beccalli *et al*. (2006) use the stochastic frontier approach (SFA) and data envelopment analysis (DEA) to measure bank cost efficiency of European listed banks operating in five countries, namely; France, Germany, Italy, Spain and the UK in the year 2000. Their findings show that, using both SFA and DEA, changes in bank cost efficiency affect stock returns positively and significantly. This suggests that stocks of cost efficient banks outperform stocks of inefficient banks. However, the impact of DEA efficiency estimate changes is more significant (at 1%) than changes of efficiency estimates generated by SFA (at 10%).

Sufian and Majid (2007) also examines the association between bank efficiency and stock prices in Malaysia. The authors adopt the DEA to estimate cost efficiency and profit efficiency of nine Malaysian commercial banks listed on the Kuala Lumpur Stock Exchange over the period 2002-2003. Sufian and Majid (2007) observe a positive and significant relationship between both cost and profit efficiencies and stock returns. However, the profit efficiency model seems to better explain stock returns (63%) compared to cost efficiency model (33%), besides that the correlation coefficient with stock returns in the case of cost efficiency is 57% while it rises to 79% in the case of profit efficiency. This suggests that stock prices reflect better changes in profit efficiency rather than changes in cost efficiency, these results stand in line with what Chu and Lim (1998) find out in their studies.

Pasiouras *et al*. (2008) study the association between bank efficiency and stock price performance in Greece by adopting data envelopment analysis (DEA) to measure technical efficiency and scale efficiency of ten commercial banks listed in the Athens stock exchange between 2000 and 2005. Moreover, cumulative annual stock returns (CASR) calculated on monthly returns are used to measure bank stock performance for each year between 2001 and 2005. The results show that the average technical efficiency under constant returns to scale is 0.931 and it increases to 0.977 under variables returns to scale, while scale efficiency mean is 0.953 for the period 2000-2005. Furthermore, Pasiouras *et al*. (2008) find that there is a positive and significant relationship between stock performance and annual change in bank technical efficiency; however, the authors find that the annual changes in scale efficiency affect positively but insignificantly bank stock returns. This suggests that the stocks of technically efficient banks outperform their inefficient counterparts.

Another empirical study of the relationship between bank efficiency and stock performance is carried out by Ioannidis *et al*. (2008). The study investigates how bank cost and profit efficiencies affect stock performance of 260 listed banks operating in 19 Asian and Latin American countries over the period 2000-2006. The authors adopt the SFA technique to estimate cost and profit efficiencies while controlling for regulatory and macroeconomic variables. Concerning cost efficiency, the authors find that Asian banks are, on average, more cost efficient than Latin American banks, and the average cost efficiency for the entire sample stands at 92.76%. On the other hand, profit efficiency estimates are much lower, with Asian banks appearing to be more profit efficient than Latin American banks, and the total average of efficiency of all listed banks in the sample stands at 70.25%. Concerning the association between bank efficiency and stock returns, Ioannidis *et al*. (2008) find that profit efficiency is positively and significantly related to stock returns, while no significant influence of cost efficiency on stock returns is found. In other words, changes in profit efficiency are reflected in stock prices; meaning good information can be provided by profit efficiency estimates for shareholders, while changes in cost efficiency are not reflected in stock prices.

Sufian and Majid (2009) conduct a study on the relationship between bank efficiency and stock prices in China. Data envelopment analysis (DEA) is used to generate bank technical efficiency estimates for listed Chinese banks over the period 1997-2006. They find that technical efficiency is positively and significantly correlated with stock returns, meaning that banks with higher levels of managerial efficiency outperform their inefficient counterparts. In addition, the results show that pure technical efficiency has a positive and significant influence on stock returns, while scale efficiency is found to have no significant effect on bank stock returns.

Liadaki and Gaganis (2010) employ the SFA to measure bank cost and profit efficiencies of 171 listed commercial, investment, cooperative banks and bank holding companies operating in the 15 old EU countries over the period 2002-2006. The results revealed by their study show that profit efficiency changes have a positive and significant effect on stock prices, while changes in bank cost efficiency show no significant impact on stock returns. The authors attribute these results to the idea that shareholders and investors are more interested in earnings that give positive expectations regarding bank future dividend than costs. Moreover, the authors find that a possible reason why profit efficiency has a positive and significant relationship with stock returns and cost efficiency might be the incorporation of revenues in profit efficiency. Higher bank profits give better predictions of the bank performance reflected in higher stock prices at the stock market whereas lower bank costs might not be observed by the public and therefore not reflected in stock performance.

Other studies that attempt to investigate the correlation between bank efficiency and stock performance are Kirkwood and Nahm (2006), Hadad *et al*. (2011), and Aftab *et al*. (2011). Kirkwood and Nahm (2006) examine the relationship between banking efficiency and stock returns in Australia over the period 1995-2002, using the DEA to estimate cost efficiency of Australian banks in producing banking services and profits. By utilising the Capital Asset Pricing Model (CAPM) to relate bank efficiency to stock returns, the results show that changes in bank efficiency are reflected in the stock returns of the Australian banks included in the sample. Hadad *et al*. (2011) examine the technical efficiency and productivity of listed Indonesian banks and the effect of efficiency on stock performance for the period 2003-2007. Data Envelopment Analysis (DEA) is used to measure bank efficiency and Malmquist productivity index to measure bank productivity. They find a positive correlation between bank efficiency and stock returns. Finally, Aftab *et al*.

(2011) investigate the impact of bank efficiency of seven banks listed on Karachi Stock Exchange and their share performance over the period 2003-2007. Corresponding with earlier studies discussed above, the results show a positive and significant correlation between changes in annual bank efficiency and share performance of the seven Pakistani listed banks over the study period.

The aforementioned studies attempt to investigate the relationship between banking efficiencies and stock performance. Overall, the results show that there is a significant association between banking efficiency and stock performance particularly in the case of profit efficiency. This suggests that the stocks of more efficient banks outperform the stocks of less efficient banks. Moreover, from the studies it appears that profit efficiency is more informative than cost efficiency as the former explains to a larger extent the variability in stock prices than the latter.

7.2.2 Studies on Risk and Stock Performance

Equity risk premiums are important components of risk and return models in finance and in portfolio management, as clarified by the Capital Asset Pricing Model (CAPM). And as financial market deregulation, the increased competition in banking, financial innovation along with other financial and economic changes in recent years, have increased risk in banking, different studies contribute to the literature by investigating the effect of risk on the performance of bank stocks. Such studies examine different risk factors; such as market risk, interest rate risk, inflation, and capital risk, on bank stock returns in different economies in the world. In this section we take a look at some of these studies that relate risk to stock performance.

Brewer and Lee (1990) investigate the stability of the relationship between bank stock returns and market and interest rate risks in the US market over the period from 1978 to 1984. Using two index market models, they find significant differences in sensitivities of different banks to stock market movements and unanticipated changes in interest rate. On the other hand, Wetmore and Brick (1998) investigate the sensitivity of commercial bank stock returns to changes in market risk, interest rate risk, exchange rate risk, and basis risk. They use a data sample of 66 commercial banks in the US over the period 1986-

1995. They find that market risk is positively and significantly related to bank stock returns and that basis risk is only significantly related to stock returns after June, 1994.

He and Reichert (2003) study to what extent risk factors related to stock market, bond market, and real estate market explain risk premiums on financial institutions' and banks' stock returns in the US market over the period 1972-1995. Using the Flexible Least Squares (FLS) to examine such relationships, the results show that the stock market risk factor has the most significant and stable effect on risk premiums of financial institutions, banks and insurance companies. On the other hand, the bond market is the main source of instability in stock returns of the financial institutions, banks and insurance companies.

Another study carried out on bank stock returns sensitivity to risk is Al-Abadi and Al-Sabbagh (2006). They utilise CAPM to investigate the impact of market risk, interest rate risk, inflation risk on bank stock returns in Jordan from 1990 to 2003. The results show that market risk is positively and significantly associated with bank stock returns, whereas interest rate risk and inflation risk have negative effects on stock returns.

Di Iorio *et al*. (2006) investigate the relationship between interest rate risk and exchange rate risk, and stock returns of three financial sectors; banking, financial services and insurance. They use a sample of stock return data from five Euro zone countries and four non-Euro zone countries over the period from 1991 to 2004. They find that bank stock returns are more sensitive to short-term interest rate, and that financial services and insurance sectors are more sensitive to long-term interest rate. Moreover, exchange rate does not seem to significantly affect stock returns in the nine European countries. A similar study is conducted by Beirne *et al*. (2009), who examine the sensitivity of financial sector stock returns to market, interest rate, and exchange rate risks in three financial sectors; banking, financial services, and insurance. They use a sample of data related to 14 European countries in addition to the US and Japan over different periods between 1986 and 2006. The results indicate that market risk has a positive and significant influence on stock returns of the three financial sectors. On the other hand, interest rate risk and exchange rate risk have significant effects on the financial sectors stock returns; however, this effect is negative for some countries and positive for other countries.

Nonetheless, interest rate risk appears to have a much more limited effect on the insurance sector than on banking and financial services sectors.

Sensarma and Jayadev (2009) investigate the sensitivity of bank stocks to risk management of state-owned and private sector banks in India over the period 1998-1999 to 2005-2006. They include four financial risk indicators; interest rate risk, credit risk, capital risk, and natural hedging strategy, as well as market (systematic) risk. The results show that market risk has a positive and significant influence on stock returns. Also, the authors conclude that banks with better risk management capabilities reward their shareholders with higher returns on their stocks. In other words, more efficient risk management is associated with better stock performance at Indian banks.

Girard *et al*. (2010) carry out a study on the determinants of commercial bank stock returns in emerging markets. They use a sample of bank and non-bank firms from 33 emerging countries from 1986 to 2004. In addition to fundamental risk factors; size and price to book value, the authors examine the effect of different country specific factors on bank stock returns. The results show that as well as size and price to book value, country specific risk factors; namely, duration gap, bank concentration, corruption, debt servicing, socio-economic conditions and per capita GDP, also have significant impacts on the stock returns of commercial banks in emerging countries.

A recent study by Kasman *et al*. (2011) examines the impact of market risk, interest rate risk, and exchange rate risk on bank stock returns in Turkey using stock prices data related to thirteen commercial banks listed on Istanbul stock Exchange for the period 1999-2009. Their findings suggest that interest rate risk and exchange rate risk are significantly and negatively related to bank stock returns. Also, market risk is found to have a stronger influence on stock returns than interest rate risk or exchange rate risk, meaning that market return plays an important role in deciding the dynamics of returns on Turkish bank stocks. Finally, Kasman *et al*. (2011) find that interest rate and exchange rate volatility are important factors affecting the volatility of the conditional bank stock returns.

To summarise, studies that investigate the effect of bank efficiency on stock performance in different economies find that profit efficiency is more significant in affecting stock returns than cost efficiency. Also, studies that investigate the effect of risk on stock returns find that market risk is the most significant risk factor in explaining changes in stock returns of banks. This study contributes to the literature by investigating the effect of cost and profit efficiencies and different types of risk on bank stock returns in the largest number, to the best of our knowledge, of commercial banks operating in large number of the EU countries. We also investigate whether bank stocks in the old or in the new EU countries perform better during the crisis time and what impact the world financial crisis itself has on stock performance.

7.3 Methodology and Data

7.3.1 Measuring Bank Stock Return and its Determinants

7.3.1.1 Panel Data Estimation Methods

We utilise panel data to examine the relationship between bank stock performance on one side and bank efficiency and risk variables on the other side in multiple regression models. One possibility is to pool all our data together in a regression model and use the Ordinary Least Squares (OLS) to estimate the pooled regression. The pooled regression model can be defined as follows:

$$Y_{it} = \alpha_0 + \beta X_{it} + v_{it} \qquad (7.1)$$

Where: Y_{it} is the dependent variable, α_0 is the intercept, β is the vector of coefficients, X_{it} is the vector of explanatory variables, and v_{it} is the error term (Gujarati and Porter, 2009).

In spite of the simplicity of applying the pooled OLS regression, Gujarati and Porter (2009) argue that by pooling together different banks at different times the *heterogeneity* (individuality or uniqueness) that might exist among different banks is not accounted for in the regression, rather it is incorporated in the error term. Therefore, the error term might be correlated with some of the explanatory variables included in the regression model, which in turn violates the assumption of classical linear regression model that there is no correlation between the error term and the regressors. This might result in the estimated coefficients being biased and inconsistent. Baltagi (2005) points out that time series and cross-section studies carry the risk of obtaining biased results if heterogeneity is not taken into consideration. This leads us to introduce the fixed effects and random effects models.

The Fixed Effects Model (FEM)

If the heterogeneity is unobserved and correlated with the regressors then the least square estimator of the coefficient, that is used in the case of pooled OLS regression, is biased and inconsistent (Greene, 2008). The fixed effects model (FEM) takes into account heterogeneity or individuality among banks or cross-section units by letting each bank has its own intercept value that captures the differences across banks (Gujarati and Porter, 2009). This can be shown in the following regression equation:

$$Y_{it} = \alpha_i + \beta X_{it} + v_{it} \qquad (7.2)$$

This equation is the same as equation (7.1) except that the intercept here differs among banks to capture the special features of each bank; however, it is constant over time for each bank (time-invariant). Obtaining intercept for each bank is done by introducing dummy variables for individual banks and then using the OLS method to estimate the model and that is why the fixed effects model is referred to as Least-Squares Dummy Variable (LSDV) Model (Gujarati and Porter, 2009).

The Random Effects Model (REM)

Greene (2008) discusses that in contrast to the fixed effects model, if the unobserved individual heterogeneity is uncorrelated with the variables included in the model, the random effects model can be used to estimate the model that can be introduced as follows:

$$Y_{it} = \alpha_0 + \beta X_{it} + w_{it} \qquad (7.3)$$

Where α_0 is the model intercept that is constant across banks and over time, while w_{it} is the composite error term that includes the random error v_{it} and the unobserved bank specific error ε_i ; $w_{it} = v_{it} + \varepsilon_i$. In this model, the intercept is no longer treated as fixed; rather it is assumed to be random with mean value of α_0 and can be expressed as $\alpha_{0i} = \alpha_0 + \varepsilon_i$; where ε_i is a random error term with zero mean and a variance of σ_ε^2 and it reflects the individual differences in the intercept values of each bank (Gujarati and Porter, 2009)[39]. The assumptions under the random effects model are that both error components have zero mean value and constant variance (homoscedastic). The method of Generalised Least Squares (GLS) can be used in the case of random effects model.

To select between the two models; the fixed effects model and random effects model, the *Hausman test (or Durbin-Wu-Hausman test)* can be used. The null hypothesis underlying this test is that there is no correlation between the regressors and the random effects, and the FEM and REM estimators do not differ substantially. In this case, both LSDV and GLS are consistent but the OLS is inefficient, and hence REM can be used. If the null hypothesis is rejected then the FEM is preferred to the REM because the random effects are probably correlated with one or more explanatory variable (Greene, 2008).

7.3.1.2 The Regression Models' Specification

Model (A)

In this study we examine the effect of bank cost and profit efficiencies and other factors on bank stock returns. Among the other factors are different types of risk. Merton (1973) argues that risk averse investors demand higher return in the presence of risk factors other than risk related to market portfolio. Therefore, in this model (Model A) and Model B we examine the effect of different types of risk on banks stock returns.

To examine the relationship between bank stock performance and its explanatory variables, the following multi-factor model is specified:

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[39] The random effects model is also referred to as the *error component model* (ECM) because the composite error term consists of more than one error term (Gujarati and Porter, 2009).

$$R_{ijt} = \alpha_0 + \beta_1 EFF_{ijt} + \beta_2 SIZE_{ijt} + \beta_3 EQ_{ijt} + \beta_4 TLTA_{ijt} + \beta_5 NPLTL_{ijt} + \beta_6 CRISIS + \beta_7 C\_DUMMY + \beta_8 C\_CRISIS + w_{ijt} \quad (7.4)$$

$$w_{ijt} = v_{ijt} + \varepsilon_{ij}$$

Where, the scripts *i, j,* and *t* stand for bank, country, and time (year), respectively. R_{ijt} is the cumulative annual stock returns (CASR) for year *t* in country *j;* EFF_{ijt} is the annual percentage change in bank i's efficiency (either cost or profit); $SIZE_{ijt}$ is the annual percentage change in bank i's size; EQ_{ijt} is the annual percentage change in the equity (capital) ratio of bank *i;* $TLTA_{ijt}$ is the annual percentage change of bank i's loan to assets ratio; $NPLTL_{ijt}$ is the annual percentage change in the non-performing loans ratio of bank *i;* $CRISIS$ is a dummy variable for the global financial crisis (2007-2009); C_DUMMY is a dummy variable for the old EU countries, C_CRISIS is an interactive dummy variable between old EU countries and the world crisis; w_{ijt} is the error term that contains the unobserved time-invariant bank specific effect $\varepsilon_{ij} \sim IID(0, \sigma_\varepsilon)$ and idiosyncratic disturbance $v_{ijt} \sim IID(0, \sigma_v)$; α_0 is the model intercept, while $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7, \beta_8$ are the regression model coefficients to be estimated. Bank efficiency and the other independent variables are calculated from publicly available information (accounting data); hence we expect a semi-strong form of efficient market to reflect this information.

Model (B)

In Model A, we investigate the effects of bank efficiency and bank-specific risks on bank stock performance. Three types of microeconomic risk are used in Model A so as to examine their effects on bank stock performance. However, in this model we aim to examine the effect of two macroeconomic risks; namely market risk (systematic risk) and interest rate risk on stock returns using the following basic two-factor[40] model:

[40] The two-factor model was first proposed by Stone (1974) who suggested including return on debt security as an additional factor to market return for deciding on the return of stocks.

$$R_{ijt} = \alpha_0 + \beta_1 MR_{jt} + \beta_2 NIR_{jt} + w_{ijt} \quad (7.5)$$

$$w_{ijt} = v_{ijt} + \varepsilon_{ij}$$

Where R_{ijt} is the stock return dependent variable that is defined in Model A, MR_{jt} is the return on domestic market portfolio in country *j* and time *t; NIR_{jt}* is the annual relative change in the long-term nominal interest rate for country *j* and time *t; w_{ijt}* is defined as in Model A, α_0 is the model intercept, β_1 (Beta) represents market (systematic) risk for each bank or the sensitivity of the stock of bank *i* to changes in the annual return on market portfolio (index); and β_2 captures the sensitivity of bank stock returns to interest rate risk.

7.3.1.3 Diagnostic Tests

Beggs (1988) argues that by applying more systematic testing of the empirical models, the quality of the applied econometric research can be significantly improved. Diagnostic testing is used for the relevant issues:

1- Multicollinearity

One of the assumptions of the classical linear regression model (CLRM)[41] for a multiple regression model is that there is no multicollinearity. Multicollinearity happens when two or more explanatory variables in a multiple regression are highly correlated, meaning that they vary closely with each other (Murray, 2006). Gujarati and Porter (2009) argue that the OLS estimators of the explanatory variables coefficients are best linear unbiased estimators (BLUE) if the CLRM assumptions are satisfied. If the multicollinearity exists in a multiple regression, the OLS coefficient estimators are still BLUE but have large variances and covariances, making precise estimation difficult. This means that multicollinearity might lead to obtaining high standard errors, resulting in one or more coefficients that are statistically insignificant.

Among different multicollinearity detection methods, we use the *variance-inflation factor* (VIF) to investigate whether multicollinearity exists in our model. The VIF is defined as:

[41] For more on the assumptions of CLRM, refer to Gujarati and Porter (2009).

$$VIF_k = \frac{1}{(1 - R_k^2)}$$

Where: R_k^2 is the coefficient of determination obtained from the OLS regression of the explanatory variable k against the other explanatory variables. The variance-inflation factor (VIF), measures how inflated the variance of an estimator is in the presence of multicollinearity. The variance of an estimator increases as the extent of collinearity increases. It has been suggested that as a rule of thumb, if the VIF of a variable exceeds 10, then that variable is said to be highly collinear (Gujarati and Porter, 2009).

2- Heteroscedasticity (*or Heteroskedasticity*)

Another assumption of the classical linear regression model (CLRM) is that the conditional variance of the error term (σ^2) is constant or the same regardless of the values that the explanatory variables take, and this assumption is referred to as homoscedasticity. If the variance of the error term varies across cross-sections (σ_i^2) , the error term or the disturbance is said to be heteroscedastic (Hsiao, 2003). Then the most likely source of heteroscedasticity in panel data studies is cross-sectional. Murray (2006) argues that the OLS estimator in the presence of heteroscedasticity is still unbiased; however it is inefficient, meaning that it is not BLUE anymore. The author adds that heteroscedasticity invalidates the t-test and F-test as a result of the misestimation of the variances. According to Gujarati and Porter (2009), using the usual testing procedures in the presence of heteroscedasticity might generate misleading results.

Different procedures have been suggested for detecting heteroscedastisity, but in this study we use Breusch-Pagan/Cook-Weisberg Lagrange Multiplier (LM) test[42]. Breusch and Pagan (1979) have suggested Lagrange Multiplier (LM) test of the hypothesis that $\sigma_i^2 = \sigma^2 f(\beta_0 + \beta' Z_i)$, where Z_i is a vector of explanatory variables. The null hypothesis is that the model is homoscedastic ($\beta' = 0$). The test follows the chi-squared distribution

[42] [42] Breusch and Pagan (1979), Cook and Weisberg (1983) and Godfrey (1978) have suggested similar test for heteroscedasticity and that is why it is referred to this test as Breusch-Pagan/Cook-Weisberg test or Breusch-Pagan/Godfrey test.

with degrees of freedom equals to the number of the explanatory variables while the error term is assumed to be normally distributed (Greene, 2008).

3- Autocorrelation (Serial Correlation)

The classical linear regression model (CLRM) assumes that there is no autocorrelation between the disturbances of observations; in other words, the disturbance term related to one observation is independent or not influenced by the disturbance term of any other observation. Gujarati and Porter (2009: 413) define autocorrelation as "correlation between members of series of observations ordered in time, as in time series, or space, as in cross-sectional data." However, the authors argue that autocorrelation is more likely to exist in time-series data where observations follow a natural ordering over time leading to intercorrelations between successive observations, while in the case of cross-section studies data are often collected from random cross-sectional units making the existence of possible correlation among the observations weak.

As in the case of heteroscedasticity, OLS estimators are still unbiased and consistent but they are inefficient anymore when the disturbances are serially correlated (Murray, 2006). Wooldridge (2010) suggests an autocorrelation test for panel data which requires two steps: first, the residual from the pooled OLS regression is obtained, and second, the residual is regressed against its first lag and estimate the coefficient. Under the null hypothesis of *Wooldridge test,* there is no serial correlation, while the alternative hypothesis assumes that the error is a first-order autoregressive process.

7.3.2 Variables Specification and Definition

From the sample used in our first empirical analysis, in which bank efficiency is measured, we keep only the listed commercial banks for which we have data on stock prices for at least two subsequent years so as to calculate the return on those stocks and remove the rest of the observations. Therefore, we produce a sub-sample of only listed commercial banks that have available data for all control and environmental variables used in the efficiency analysis as well as data concerning stock return and its determinants. As a consequence of these restrictions, the generated sample of banks in this chapter is kind of limited. Stock prices data are collected from Bankscope database on a monthly basis for all the EU countries from 2004 to 2010 and for which we have stock prices data. After taking the annual change in bank efficiency and some other explanatory variables, the final sample is an unbalanced panel dataset composed of 538 observations corresponding to 141 commercial banks over the period 2005-2010. This dataset includes 105 banks from the old EU countries and 36 banks from the new EU countries with Denmark having the largest number of banks in the sample (38 banks). Appendix 5a summarises the number of banks and observations included in the sample for each country over the six years under study.

In this section we define the dependent variable (stock returns) and the explanatory variables that mainly include bank efficiency and risk variables. The potential effects of such variables and the expected signs of their influence on bank stock returns are also discussed.

The Dependent Variable

The dependent variable is the cumulative annual stock returns (CASR) that can be defined as follows:

$$\text{CASR in year } t = \big((1 + month\ 1\ return) * (1 + month\ 2\ return) * \ldots * (1 + month\ 12\ return)\big) - 1 \qquad (7.6)$$

The cumulative annual stock returns (CASR) approach to calculate stock returns has been adopted in recent studies such as Pasiouras *et al*. (2008), Liadaki and Gaganis (2010) and Aftab *et al*. (2011). Other studies use different methods to calculate stock returns such as adding daily returns to calculate annual returns (Beccalli *et al*., 2006) or using end-of-the year stock prices (Chu and Lim, 1998).

The Independent Variables

Model (A)

In equation (7.4) the independent variables are defined as follows:

- **Cost Efficiency**

To investigate whether changes in cost efficiency are reflected in changes in bank stock prices, the stock returns are regressed against the annual percentage change in cost efficiency calculated as: $[(Eff_t - Eff_{t-1})/Eff_{t-1}]$. Beccalli *et al*. (2006), Sufian and Majid (2007), Chu and Lim (1998) and Eisenbeis *et al*. (1999) find cost efficiency change to have a positive and significant relationship with bank stock returns, while Liadaki and Gaganis (2010) and Ioannidis *et al*. (2008) find this variable to have no significant influence on stock returns. To further examine the effect of cost on stock returns we use the annual change in *cost-to-income* ratio instead of the cost efficiency to see if accounting based variable can generate similar results. Appendix 5b provides descriptive statistics for the ratio of cost to income for the three EU groups, the entire EU, the old and the new EU countries. The table shows that the mean cost to income ratio is slightly higher (at 62.3%) in the old countries than in the new EU countries (at 61%). Moreover, from the graph in Appendix 5b it can be seen that cost relative to income at banks increases significantly during the crisis time particularly in the case of the old EU countries at year 2008, while this increase is not as high in the new EU countries. In this study we expect cost efficiency to have a positive effect on stock returns while we expect cost-to-income ratio to have a negative effect.

- **Profit Efficiency**

The effect of the annual percentage change in profit efficiency on bank stock returns is also investigated in this study. The aim is to see if the profit efficiency changes are reflected in stock prices, or in other words, we examine the informativeness of profit efficiency with regard to stock prices. The annual percentage change in profit efficiency is calculated the same way as the cost efficiency change. In comparison with cost efficiency, Liadaki and Gaganis (1020), Sufian and Majid (2007), Ioannidis *et al*. (2008) and Chu and

Lim (1998) find that profit efficiency is more informative and has stronger influence on stock prices than cost efficiency. This means that shareholders and potential investors are more concerned about profits as they give an indication for potential dividend in the future. The annual change in the accounting-based ratio of *return on equity*[43] is also used as an alternative to profit efficiency to examine if it has similar influence on stock returns. From the table in Appendix 5b, banks in the new EU countries maintain on average higher return on equity ratio (at 11%) than banks in the old EU countries (at 7.6%). Furthermore, from the ROE graph it can be seen that this ratio decreases significantly from year 2007 onward for all the EU groups as a consequence of the world financial crisis. However, this ratio starts to increase after the year 2009 in the new countries while it decreases in the case of the old EU countries probably as a consequence of the sovereign debt crisis in the GIIPS countries. In this study, both changes in profit efficiency and return on equity are expected to have positive effects on stock returns.

- **Size**

This variable is obtained by calculating the annual percentage change in the total assets of banks. Brown *et al*. (1983) argue that the effect of size on stock return is not constant over time, rather it is sensitive to time period studies. Claessens *et al*. (1998) find a positive and significant relationship between size and stock return in eleven emerging markets. They attribute this result to the idea that some of those markets are opened to foreign investors who are attracted to larger firms which increase their stock returns, or it might be attributed to the study period they use. Also, they point out that larger firms might have access to cheaper capital either domestically or internationally making their shares more attractive. Another possibility is that larger firms benefit more from trade and other reforms in those markets compared to the smaller firms. Pasiouras *et al*. (2008), Sufian and Majid (2009) and Girard *et al*. (2010) find that bank size positively affects stock performance. On the other hand, Fama and French (1992) in the US and Chan *et al*. (1991) in Japan suggest a negative relationship between firm size and stock returns as well as Beccalli *et al*. (2006) who find a negative influence of bank size on stock returns.

[43] Cost-to-income and return on equity ratios data are collected from Bankscope database.

Because we have a large sample from 24 EU countries, we do not have expectation with regard to the effect of bank size on stock returns.

- **Equity Ratio (Insolvency Risk)**

As discussed in Chapter 2, banks maintaining higher capital ratio (lower leverage) are less risky because they can absorb unexpected losses and hence implicitly protect their depositors and other creditors. However, higher capital means less profits and lower returns on equity (ROE) as explained by the equation: $ROE = ROA \times \frac{Assets}{Equity\ Capital}\ (or\ equity\ Multiplier)$, which in turn might affect negatively the performance of stocks. However, Sensarma and Jayadev (2009) argue that as lower capital ratio means higher insolvency risk which might lead into bankruptcy, some shareholders are more concerned with the long-term sustainability of a bank so as to continue its distribution of profits; hence capital ratio would have a positive effect on stock returns. Sensarma and Jayadev (2009) and Beccalli *et al*. (2006) find equity ratio to affect positively bank stock returns, while Pasiouras *et al*. (2008) obtain a reverse effect. The annual percentage change in the ratio of equity to total assets is used to represent this variable and we do not have expectations regarding how this variable might affect stock returns in this study.

- **Total Loans/Total Assets (Liquidity Risk)**

The annual percentage change in the ratio of total loans to total assets is also included in the model to see if liquidity risk is reflected in the stocks' price returns. Chen *et al*. (2010) find that liquidity risk might lower profitability measured by ROA and ROE because banks with larger liquidity gap lack cheap funds and might use their liquid assets or borrow externally to meet the demand of fund. This in turn would increase the cost of funding and therefore lower profitability making the bank's stock undesirable for investors. In this sense, higher liquidity risk might lower bank stock price returns meaning a negative relationship between liquidity risk and stock returns is expected and as found also by Sufian and Majid (2009).

- **Non-Performing Loans/Gross Loans (Credit Risk)**

The effect of credit risk as represented by the annual percentage change in the ratio of non-performing loans to total gross loans on stock performance is also examined. Investors might be reluctant to buy stocks belonging to banks with high credit risk. Furthermore, higher provisions might be allocated by banks with higher levels of non-performing loans which in turn affect negatively the profitability of banks making their shares unattractive for investors. Sensarma and Jayadev (2009) use provision to total assets ratio as a measure for credit risk and they find a positive but insignificant relationship between this variable and stock returns. As the level of non-performing loans to gross loans is the measure of credit risk to be used in this study, we expect this measure to have a negative effect on stock returns[44].

- **World Financial Crisis (2007-2009)**

The dummy variable created earlier in this thesis for the period (2007-2009) is used to measure the effect of the global financial crisis on stock returns in the EU. The European Union stock markets were brought down after the crisis hit the US stock markets severely. This can to a great extent be attributed to the financial contagion[45] from the stock markets in the United States to the stock markets of the EU during the crisis time as the markets in the two regions are financially integrated to rather high degree. Munoz *et al*. (2011) and Hwang *et al*. (2010) confirm the existence of financial contagion from the US stock markets to the European stock markets during the subprime crisis time. Therefore, we expect a negative influence imposed by the crisis on the EU bank stock performance. Also, the credit crunch prevailed over the period of crisis might have decreased the profits generated by commercial banks, sending a negative signal to investors which in turn deteriorates the bank's stock returns.

[44] With regard to this variable, we run separate regression in which we include banks for which data regarding this variable is available.

[45] Forbes and Rigobon (2002: 2223) define *contagion* as "a significant increase in cross-market linkages after a shock to one country or group of countries", while they refer to any continued market correlation at high levels as *interdependency*.

- **Country Dummy**

To verify if bank stocks perform better in the old EU countries than in the new EU countries or not, we investigate the effect of the old EU country dummy variable that is created earlier in this thesis on stock returns. Because our aim here is just to investigate whether bank stocks perform differently between the old and the new countries, we use this dummy variable rather than running a regression model for the two groups, as done in Chapter 6. The expected impact of this variable on stock returns is unknown in this study. Although the economic and financial conditions in the old EU countries might be better than they are in the old EU countries, which might affect positively stock performance in the first group, commercial banks in the new EU states might generate higher profits as they operate in a less competitive banking environment making a positive impact on stock prices compared to the old EU countries.

- **Country Dummy * Crisis**

This interactive variable created earlier in Chapter 4 is also used to examine whether the crisis has affected bank stocks more in the old or in the new EU countries and in what direction. Because financial markets and institutions in the old EU countries are more likely to be integrated with the US markets and to a larger extent than those in the new countries, then we expect that financial contagion from the US stock markets to the stock markets in the old EU is stronger and more effective compared to the new EU countries' stock markets during the crisis time. Furthermore, banks' profits are expected to deteriorate more in the old EU countries during the credit crunch time than in the new EU countries, which in turn might affect negatively stock returns in those countries. For these reasons, the expected effect of this variable on stock returns is negative.

Model (B)

In equation (7.5) the independent variables are defined as follows:

- **Market Return (Market Risk)**

Market stock return is calculated for each year by adding monthly returns on domestic market index collected from Datastream database for the whole year period. The monthly return is calculated using the formula :[$(MR_t - MR_{t-1})/MR_{t-1}$]. The coefficient of this variable (Beta) measures the relative riskiness (market risk) of bank stock *i* in comparison with the market portfolio as a whole. In the literature overall, the well-known relationship between this variable and stock return is positive. For instance, in the banking literature this variable is found to have a positive and significant impact on bank stock return by Eisenbeis *et al*. (1999), Brewer and Lee (1990), Haq and Heaney (2009), Wetmore and Brick (1998) and Kasman *et al*. (2011). Therefore, we expect a positive relationship between this variable and bank stock returns.

- **Nominal Interest Rate (Interest Rate Risk)**

In addition to market returns, the annual relative change in the long-term interest rate of each country is accounted for in Model B to measure the sensitivity of bank stock returns to interest rate. Kane and Unal (1988) argue that banks are consistently sensitive to long-term rates, and Kwan (1991) points out that bank stocks are more sensitive to long-term interest rates. Therefore, long-term interest rates are used rather than short-term interest rates. Data regarding the long-term government bond yield is collected from the Datastream database to represent this variable. Changes in interest rates might affect a bank's net interest margin and therefore return on assets (ROA), and finally shareholders (Sensarma and Jayadev, 2009). Flannery and James (1984) argue that according to the nominal contracting hypothesis, the sensitivity of a firm's common stock returns to changes in interest rate depend on the firm's holding of net nominal assets and the maturity composition of the net nominal assets held. Eisenbeis *et al*. (1999) and Al-Abadi and Al-sabbagh (2006) find a negative relationship between interest rate and bank stock returns, while Kasman *et al*. (2001), Iorio *et al*. (2005), Wetmore and Brick (1998) and Brewer and Lee (1990) find mixed results with regards to this relationship. In this study, we do not have expected sign for the influence of this variable on bank stock returns. Appendix 5c summarises the explanatory variables in Model A and Model B along with their description and the expected sign of their effects on bank stock returns.

Table 7.1 presents summary statistics for bank stock returns, domestic stock market returns and interest rate returns for the old and the new EU countries as well as for the entire EU region over the period 2005-2010[46]. The table shows that the annual mean bank stock return is 2% for the old EU countries while it is higher and stands at 7.4% for the new EU countries. The volatility of stock returns ranges from 45.7% and 50.8% in the old and new EU countries, respectively. In contrast, the mean domestic market return is higher for the old EU countries (at 7.2%) with lower volatility than it is for the new EU states (at 3.4%). The table also indicates that contrary to the new EU countries, the interest rate return is negative on average for the old EU member states. Regarding the entire EU region, stock returns, market returns and interest rate are, on average, 3.3%, 6.3% and 0.9%, respectively.

Table 7.1 Descriptive Statistics of Bank Stock Returns and Risk Factors

Country Sample	Variables	*Mean*	*Median*	*S.D.*	*Max.*	*Min.*	*Skew.*	*Kurt.*	*Obs.*
EU27	R	0.033	0.018	0.47	2.42	-0.982	1.138	6.341	538
	MR	0.063	0.217	0.416	1.036	-1.444	-1.267	3.783	538
	NIR	0.009	0.006	0.204	1.496	-0.602	2.776	20.288	538
EU15	R	0.02	0.021	0.457	2.42	-0.982	1.183	7.201	410
	MR	0.072	0.225	0.383	0.559	-1.04	-1.27	3.325	410
	NIR	-0.006	-0.001	0.161	0.757	-0.256	1.332	8.092	410
EU12	R	0.074	-0.02	0.508	1.857	-0.849	0.989	4.356	128
	MR	0.034	0.185	0.508	1.036	-1.444	-1.118	3.595	128
	NIR	0.057	0.014	0.298	1.496	-0.602	2.736	14.817	128

Note: R is bank stock return, MR is market index return, , NIR is nominal interest rate return, S.D.is standard deviation, Max.is the maximum value, Min.is the minimum value, Skew.is the skewness, Kurt.is kurtosis, and Obs.is the number of observations.

Figure 7.1 illustrates the average annual returns of bank stocks and domestic stock index for the period 2005-2010. Overall it is possible to notice very similar patterns in the two graphs where the average returns crashes significantly in 2008 during the global financial crisis. The stock return trends jump in 2009 and rise to a higher level than they are before the crisis, but decline again in 2010, probably as a consequence of the Eurozone crisis.

[46] In this chapter we do not create GIIPS sample because of data limitation. The sub-sample generated for listed banks is fairly small and creating a sub-sample for the GIIPS countries would not generate consistent results. For this reason, we aim only to make a comparison between the old and the new EU member states.

Although the trends of stock returns for banks and domestic market index are similar for both the old and the new EU countries, bank stock in the new countries show slightly better performance from 2007 onward, while the trend is almost parallel for the domestic index return between the two groups, particularly between 2007 and 2009. Appendix 5d indicates that the correlation between bank stock returns and domestic index return is positive and statistically significant on average for the whole sample at 1% level.

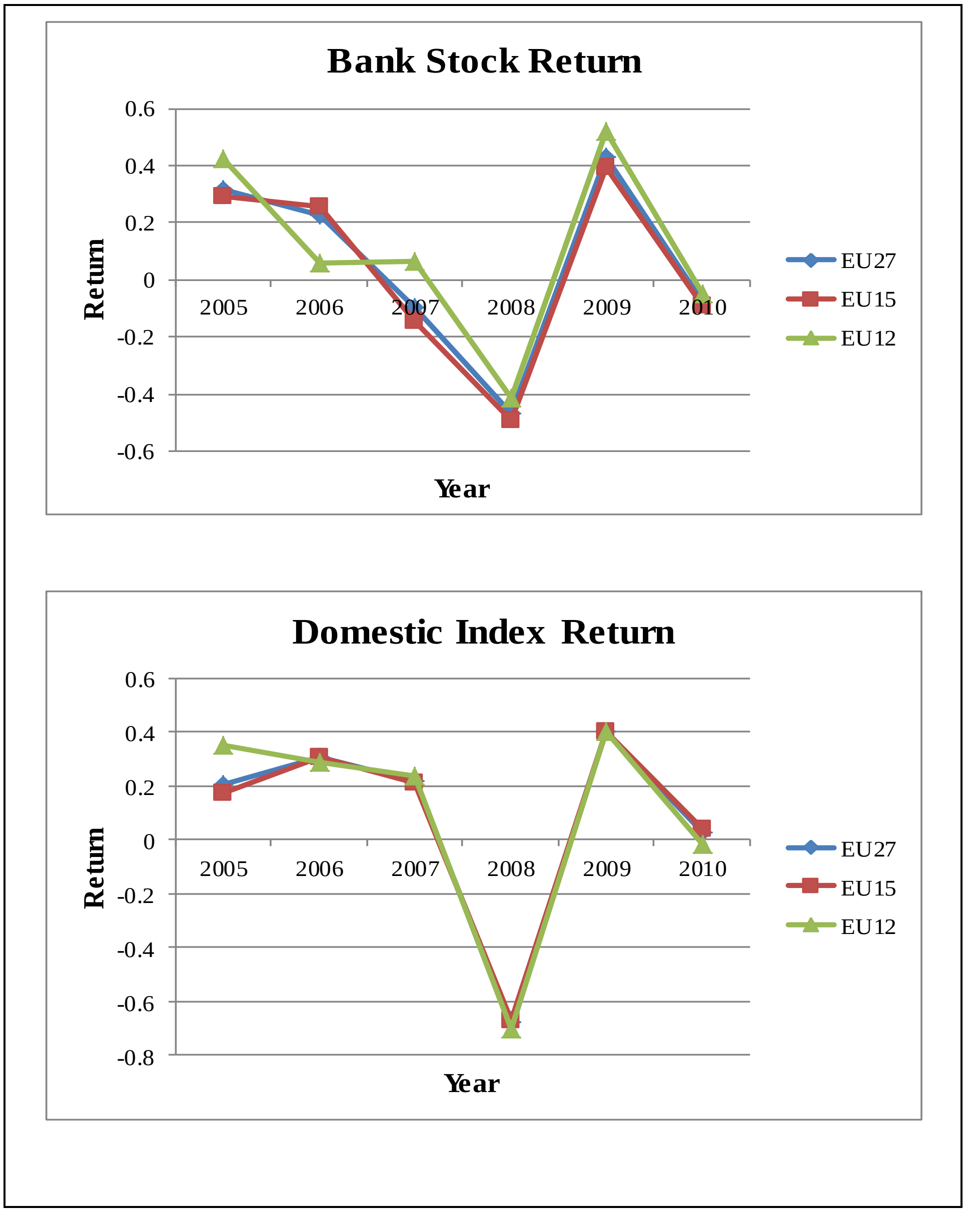


Figure 7.1. Stock Returns of Banks and Market Indices

7.4 Empirical Results: Analysis and Discussion

It is argued that stock performance might be the ultimate measure of firm efficiency. If bank stock prices reflect all the information about the past, present and expected future performance of a bank, then this measure would be a more reliable indicator of bank efficiency. However, even if the choice of measures is correct, the previously described measures of efficiency may only be related to stock performance in the long run, while the short variations may not be explained by efficiency measures. In such cases, individual bank effects may explain the majority of total variations in stock performance. As explained in section 7.3.1, the main focus in the explanatory variables of bank stock returns is on bank cost and profit efficiencies along with risk variables. We start by reporting and analysing regression results for Model (A) then for Model (B).

7.4.1 Model (A) Regression Results

For Model (A) we run four separate regressions. In each of them we include different bank cost or profit efficiency measures as reported in Table 7.2. In Model I the change in cost efficiency is included as an independent variable, while in Model II the change in the ratio of cost to income is used instead as a measure of cost efficiency. Model III includes the change in profit efficiency, while Model IV uses the change in the ratio of return on equity as a measure of profit efficiency. The liquidity risk variable (total loans/total assets) and the credit risk variable (non-performing loans/gross loans) did not add value to the models as their coefficients appear to be insignificant in all the four models[47]. We also ran the *Wald* test for these two variables and the value of *Wald* test appeared to be insignificant at 5%, indicating that the null hypothesis assumption that the two coefficients equal to zero is not rejected. This means that these two risk variables do not have significant effects on bank stock returns; or to put it another way, the annual changes of the two risk ratios are not reflected in the bank stock returns. Therefore, we omit these two variables and run the four models without including them in the regression. This leads to new modified equation for Model A that takes the following form:

[47] Separate regression models were run when including the ratio of non-performing loans to gross loans due to missing data before this ratio appeared to be insignificant in all the four models.

$$R_{ijt} = \alpha_0 + \beta_1 EFF_{ijt} + \beta_2 SIZE_{ijt} + \beta_3 EQ_{ijt} + \beta_6 CRISIS + \beta_7 C_{DUMMY} + \beta_8 C_{CRISIS} + w_{ijt} \quad (7.7)$$

$$w_{ijt} = v_{ijt} + \varepsilon_{ij}$$

All four models in Table 7.2 are for panel data regressions using the cumulative annual stock returns (CASR) as dependent variable, and they all are estimated using random effects (RE). The choice of using random effects (RE) for estimation is determined by *Hausman test* which appears to generate insignificant Chi-square value for all the four models indicating the appropriateness of using random effects, as reported in the lower panel of Table 7.2[48]. Models I-IV do not suffer from the problem of multicollinearity as indicated by the variance inflation factors (VIF) which range from 1.20 to 5.57 in all the models. The Breusch-Pagan/Cook-Weisberg test for heteroskedasticity indicates that only Models II and Model III suffer from heteroskedasticity, as reported in the lower panel of the table where the value of Chi-square is significant. We use Eicker–Huber–White (heteroskedasticity-robust standard errors) to correct for heteroskedasticity in Models II and Model III, as suggested by Wooldridge (2010)[49]. These standard errors are asymptotically valid in the presence of any kind of heteroskedasticity, including homoskedasticity. Heteroskedasticity causes standard errors to be biased as OLS assumes that errors are both independently and identically distributed. Robust standard errors relax one or both of these assumptions, making them more reliable. Furthermore, the lower panel of the table shows that the Wooldridge test for autocorrelation generates insignificant F-value for all the models, meaning the null hypothesis that there is no serial correlation cannot be rejected. The lower panel also reports the Wald-test, which appears to be highly significant for all the models, meaning that the null hypothesis that all the model coefficients equal to zero is rejected at 1%. Additionally, the coefficient of determination (R-squared)[50] and the number of observations are reported in Table 7.2

[48] Also, we test the validity of random effects as opposed to OLS based on Breusch and Pagan Lagrange Multiplier test; results reveal significant Chi-square values for the four models indicating the validity of using random effects models.
[49] Also, see Gujarati and Porter (2009).
[50] R-squared measures the goodness of fit or how well the regression line fits the data. In other words, it measures to what extent the variation in the dependent variable can be explained by the variations in the explanatory variables. For more, see Gujarati and Porter (2009).

lower panel too. Appendices 6a-6d show the regression diagnostic tests including VIF, Breusch-Pagan/Cook-Weisberg test, Wooldridge test and Hausman test, for all the four models as generated by STATA12 software package.

Table 7.2 Determinants of Stock Returns (Model A)

Variables	Model I RE	Model II RE-Robust	Model III RE-Robust	Model IV RE
CONS	0.057 (0.060)	0.053 (0.041)	0.012 (0.043)	0.061 (0.060)
CE	0.745** (0.359)			
C/I		-0.591*** (0.117)		
PE			0.749** (0.342)	
ROE				0.124* 0.064)
SIZE	0.320*** (0.107)	0.209** (0.094)	0.359*** (0.105)	0.314*** (0.106)
EQ	0.539*** (0.072)	0.453*** (0.088)	0.520*** (0.128)	0.524*** (0.072)
CRISIS	-0.023* (0.0298)	-0.029* (0.0266)	-0.112* (0.032)	-0.101* (0.021)
C_DUMMY	0.055 (0.067)	0.064 (0.048)	0.071 (0.046)	0.050 (0.089)
C_CRISIS	-0.229** (0.091)	-0.184** (0.081)	-0.219*** (0.078)	-0.197** (0.089)
R-sq	0.321	0.332	0.398	0.345
Wald Test	100.54***	105.13***	116.55***	106.21***
Hausman Test	4.72	8.62	1.84	2.06
Wooldridge Test	0.982	0.918	1.506	1.221
BP/CW LM Test	1.13	8.20***	6.35**	0.65
No. of Obs	538	538	538	538

Note: ***, ** and * indicate 1%, 5% and 10% significance levels, respectively, and asymptotic standard errors in parentheses. CE is percentage change in cost efficiency, C/I is percentage change in cost/income ratio, PE is percentage change in profit efficiency, ROE is percentage change in return on equity, SIZE is bank size, EQ is equity ratio, CRISIS is the world financial crisis 2007-2009, C_DUMMY is old countries dummy variable, and C_CRISIS is old countries and crisis interactive variable. Regression results generated using STATA12 software.

- **Cost Efficiency**

From Table 7.2 it can be seen that according to Model I, the coefficient of cost efficiency (measured by SFA) change has a positive and significant (at 5%) effect on bank stock returns. This suggests that stocks of cost efficient banks outperform their inefficient counterparts. The value of the coefficient is 0.745 meaning that an increase by 1% in the bank cost efficiency would lead to a 0.745% increase in stock returns. These results stand in line with the results obtained by Beccalli *et al*. (2006), Sufian and Majid (2007), Chu and Lim (1998) and Eisenbeis *et al*. (1999). When using the accounting based cost-to-income ratio instead of SFA-based cost efficiency in Model II, we find this variable to have a negative and highly significant influence on stock returns. This means that the stocks of banks with lower levels of cost relative to income outperform their peers with higher cost ratio. The results from Model I and Model II suggest that both SFA-based cost efficiency and accounting-based cost efficiency produce informative efficiency measures whose changes are reflected in the changes of stock prices. However, the model that includes cost efficiency (Model I) explains around 32.1% (R-squared =0.321) of the variability in stock prices, while Model II that includes a traditional accounting-based ratio (cost/income) explains the slightly higher (33.2%) stock price variability.

- **Profit Efficiency**

With regard to profit efficiency, from Model III in Table 7.2 the coefficient of profit efficiency (measured by SFA) change is positive and significant (at 5%) meaning that profit efficiency change has a positive and significant relationship with stock returns. Therefore, it can be concluded here that the stocks of profit efficient banks outperform their counterparts. An increase of 1% in the bank profit efficiency would increase bank stock returns by almost 0.75%. In Model IV we find a positive and significant (at 10%) relationship between ROE and stock returns. This suggests that banks with higher ROE outperform banks with lower ROE in terms of stock performance. The results from Models III and Model IV indicate that both SFA-based profit efficiency and accounting-based profit efficiency produce informative efficiency measures whose changes are reflected in the changes of stock prices. However, Model III explains about 40% (R-squared =0.398) of the variability in stock prices compared to 34.5% in Model IV, meaning that changes in the SFA-based profit efficiency is more informative than the traditional accounting-based ratio (ROE). Ioannidis *et al*. (2008) argue that profit efficiency changes provide more information about the quality and persistency of earnings than the ROE as the former take into account input and output considerations simultaneously via economic optimisation mechanisms.

From Table 7.2 we can also conclude that profit efficiency in Model III tends to better explain (is more informative) the variations in stock returns compared to cost efficiency in Model I as indicated by the aforementioned values of R-squared. This means that shareholders and potential investors are more concerned about profits as they give an indication for potential dividend in the future. Or in other words, rational shareholders are supposed to be interested in their eventual wealth generated by dividend payments or capital gains. Therefore, stock returns are more sensitive to profit efficiency than to cost efficiency because dividends are paid on the basis of profits. In addition, cost efficiency will not necessarily result in higher profits because that is subject to revenue efficiency as well (Ioannidis *et al*., 2008). Similar results are obtained by Liadaki and Gaganis (1020), Sufian and Majid (2007), Ioannidis *et al*. (2008) and Chu and Lim (1998).

- **Size**

With regard to bank size, Table 7.2 shows that the coefficient of this variable is positive and highly significant in all models I-IV. This means that larger banks' stocks outperform smaller banks' stocks and generate higher returns. The positive and significant relationship between bank stock returns and bank size might be attributed to the notion that larger banks might have access to cheaper capital either domestically or internationally making their shares more attractive. In other words, larger banks are more efficient in minimising their operating costs that in turn would lead to higher earnings, which would translate into higher stock returns. Also, larger commercial banks might generate higher profits due to lower costs resulted from exploiting economies of scale and economies of scope, which in turn affect positively stock returns. Or furthermore, larger banks might be considered too-big-to-fail which encourage them to take on higher risks (moral hazard) and generate more profits leading to higher stock returns. Similar to our results, Pasiouras *et al*. (2008), Sufian and Majid (2009) and Girard *et al*. (2010) find a positive association between bank size and stock returns.

- **Equity Ratio (Insolvency Risk)**

Equity ratio enters the four models with a positive sign, meaning that equity ratio has a positive and highly significant influence on bank stock returns. In other words, the stocks of banks with lower levels of insolvency risk outperform the stocks of more risky banks. This can be attributed to the idea, as Sensarma and Jayadev (2009) argue, that as lower capital ratio is associated with higher insolvency risk, shareholders are more concerned with the long-term sustainability of a bank so as to continue its profit distribution. Also, and for the same reason, banks with a higher equity ratio are considered less risky by lenders, and hence such banks might be able to reduce their costs and increase their profits by borrowing more cheaply, which in turn positively affect stock performance. Sensarma and Jayadev (2009) and Beccalli *et al*. (2006) also find a positive relationship between equity ratio and bank stock returns.

- **World Financial Crisis (2007-2009)**

Not surprisingly, Table 7.2 reports a negative and significant (at 10%) effect of the world financial crisis on bank stock returns in all the four models estimated. This means that bank stock performance during the crisis time is worse than it is in non-crisis time. As discussed earlier, banks' profit decreases over the credit crunch prevailed during the crisis time due to weaker investing and lending activities and the losses banks faced as well as higher costs during the crisis period. The lower profitability over the crisis time might have sent negative signals to investors regarding the performance of banks which in turn deteriorates the stock returns. Also, this might be enhanced by financial contagion that spread from stock markets in the US to the European stock markets that were hit severely during the crisis, as was proved by Munoz *et al*. (2011) and Hwang *et al*. (2010). This contagion might have caused panic in the EU financial markets during the crisis which urged investors to sell their stock investments leading to lower stock prices and lower returns as a consequence.

- **Country Dummy**

The dummy variable coefficient for the old EU countries appears positive but insignificant in all the estimated models. Therefore, there is no evidence that stock performance significantly differs between commercial banks in the old and the new EU member states over the six years under study. As we discussed earlier, although the economic and financial conditions in the old EU countries might be better than they are in the new EU countries which might affect positively stock performance in the first group, commercial banks in the new EU countries operate in a less competitive markets and might generate higher profits leading to higher stock returns.

- **Country Dummy * Crisis**

This interactive variable appears to be negatively and significantly related to bank stock returns in all models. This suggests that the negative effect of the world financial crisis on stock returns is stronger for banks operating in the old EU countries than their counterparts in the new EU countries. This might be attributed to the case that financial markets in the old EU countries are more integrated and correlated with financial markets in the US than those in the new EU countries, making potential contagion from US stock markets to the old EU countries' stock markets stronger and more effective. This stands in line with what we earlier found in this thesis that banks in the new EU countries appear to be more profit efficient during the crisis time than their peers in the old EU countries. The lower profitability of banks in the old EU members during the crisis might explain the worse bank stock performance in those countries during that time.

7.4.2 Model (B) Regression Results

Model B in Table 7.3 is estimated using fixed effects (FE) as the Hausman test in the lower panel of the table generates significant Chi-square supporting the use of fixed effects. The model does not suffer from the problem of multicollinearity as indicated by the variance inflation factor (VIF) which takes a value of one meaning no highly correlated independent variables exist. The Breusch-Pagan/Cook-Weisberg test for heteroskedasticity indicates that the model suffers from heteroskedasticity as Chi-square is significant. Furthermore, the Wooldridge test in the table reveals significant F-value for this model, supporting the existence of serial correlation. Verbeek (2008) argues that the presence of autocorrelation invalidates standard errors and resulting tests and hence the regression estimators are no longer efficient. As the model suffers from heteroskedasticity and autocorrelation, the regression is estimated with robust and clustered standard errors (cluster-robust covariance matrix *or* cluster-robust-VCE-estimator) on the group variable (*id*). Baum (2006) argues that this estimator is robust to the correlation of disturbances within groups and to not identically distributed disturbances. Also, the F-test is shown in the lower panel of Table 7.3 and it appears to be highly significant, rejecting the null hypothesis that all the model coefficients are equal to zero. The coefficient of determination (R-squared) is also reported in the table. Appendix 6e shows the regression diagnostic tests including VIF, Breusch-Pagan/Cook-Weisberg test, Wooldridge test and Hausman test, for Model B as generated by STATA12 software package.

Table 7.3 Determinants of Stock Returns (Model B)

Variables	**FE-Robust**
CONS	-0.011***
	(-0.003)
MR	0.722***
	(-0.44)
NIR	-0.143**
	(-0.012)
R-sq	0.373
F-Test	134.00***
Hausman Test	7.01**
Wooldridge Test	6.985***
BP/CW LM Test	42.94***
No. of Obs	538

Note: ***, ** and * indicate 1%, 5% and 10% significance levels, respectively, and asymptotic standard errors in parentheses. CONS is the constant, MR is domestic market return and NIR is nominal interest rate. Regression results are generated using STATA12 software.

- **Market Return (Market Risk)**

The coefficient of market return (MR) is, as expected, positive and highly significant (at 1%) as reported in Table 7.3. This suggests that return on market index has a positive and significant influence on individual commercial banks' stock returns and the latter increases by 0.722% as the former increases by 1%. The coefficient of this variable (Beta) represents the systematic risk of bank stock returns or how sensitive the commercial stock returns to the return on market index. This model explains 37% of the variability in bank stock return indicating substantial non-systematic risk. This finding is consistent with the findings of Eisenbeis *et al.* (1999), Brewer and Lee (1990), Haq and Heaney (2009), Wetmore and Brick (1998) and Kasman *et al*. (2011).

- **Nominal Interest Rate (Interest Rate Risk)**

From Table 7.3 the change in the long-term interest rate appears to have a negative and significant (at 5%) effect on bank stock returns. As the coefficient of this variable represents interest rate risk, it can be said that bank stock returns are significantly and negatively sensitive to changes in nominal interest rate. However, by comparing the coefficients of this variable with the coefficient of the market returns, we conclude that stock returns are more sensitive to market risk rather than to interest rate risk. The negative relationship between interest rate and stock returns might be due to the fact that interest rates might negatively affect net interest margins (profits) of banks and therefore the return on assets (ROA) and the shareholders returns in turn (Sensarma and Jayadev, 2009). Higher interest rates might raise borrowing costs for banks, increase expenses on the liabilities side, or decrease profits on the assets side, leading to lower profits and hence lower stock returns. Similarly, Eisenbeis *et al*. (1999) and Al-Abadi and Al-sabbagh (2006) find a negative relationship between interest rate and bank stock returns.

7.5 Summary and Conclusion

This chapter provides an empirical analysis of the variables affecting commercial banks' stock performance in the European Union. It starts by providing a summary of the literature review that relates stock performance to both bank efficiency and risk. With regard to stock performance and efficiency, the majority of the studies surveyed in this chapter find a positive effect of bank efficiency, measured using different frontier methods, on bank stock performance. Also, studies that relate both cost and profit efficiencies to stock returns find that profit efficiency changes explain larger variability in stock returns than changes in cost efficiency, suggesting that shareholders are more concerned about profit maximisation than cost minimisation. Regarding stock performance and risk, the studies surveyed find significant effects of different types of risk, particularly insolvency, market and interest rate risks, on bank stock returns.

This chapter introduces the methodology used to achieve the aim of this chapter. It reviews fixed effects and random effects models for panel data along with diagnostic tests employed to examine the existence of multicollinearity, heteroskedasticity and autocorrelation. Moreover, this chapter specifies two regression models to investigate the relationship between bank stock performance and different explanatory variables, particularly those related to efficiency and risk. The dataset is described and the dependent and independent variables are defined and discussed as to their expected influence on bank stock returns.

Finally, this chapter reports and analyses the empirical results generated by the two regression models. Regarding bank efficiency, the results show that cost efficiency represented by both SFA-based cost efficiency and the accounting-based cost-to-income ratio has a significant effect on bank stock returns. Profit efficiency, also measured by both the SFA and the return on equity (ROE) is found to have a positive and significant effect on stock returns. In addition, from the results it can be concluded that profit efficiency is more informative than cost efficiency as the former explains, to a larger extent, the variability in stock returns than the latter. The results find that bank size and the level of equity (insolvency risk) affect bank stock returns positively, while credit risk and liquidity risk have no significant effect on stock returns. The world financial crisis and the interaction between this variable and the old EU countries' variable appear to have a negative and significant effect on stock performance. Finally, from the second regression model, the results suggest that market returns positively and significantly affect stock returns, whereas changes in nominal interest rate have a negative effect. However, bank stock returns appear to be more sensitive to market risk than interest rate risk in the EU region.

The key implication that can be derived from the analysis of this chapter is that bank management should improve both cost and profit efficiencies in order to generate returns and increase the wealth of the banks' shareholders. As the empirical findings show that variations in both cost and profit efficiencies are reflected in bank stock prices, then this highlights the importance for bank managers not only to maximise profits but also to minimise cost, leading to a better stock performance in the EU markets. Moreover, bank managers should maintain relatively high level of capital so as to attract shareholders who are concerned about the sustainability and consistency of the bank they invest in for future dividend distribution. Also, the results show that stock prices are sensitive to both market and interest rate risks; this should urge bank managers to hedge against such risks and employ the techniques by which they can alleviate the negative consequences of fluctuations in market factors in order to maintain stability in their stock returns.

Chapter 8

Conclusions and Limitations of the Research

8.1 Introduction and Summary of Findings

The forces of financial deregulation, the foundation of the Economic and Monetary Union (EMU) and the introduction of the Euro have contributed to the process of integration in the EU banking markets in the last few decades. The technological change also has contributed to the integration process and increased competition in the banking industry (ECB, 2010b). The old and the new EU countries have faced significant challenges with regard to financial regulations. The Second European Banking Directive, the single European Passport, the introduction of Euro and information technology advancement are all factors that have contributed to the elimination of entry barriers between the old EU countries. This has resulted in higher levels of competition and more unified banking markets. On the other hand, the new EU countries underwent major reforms and transformation and moved towards a rather liberalised and integrated financial and banking market. Hence it was deemed noticeably important to improve banks' efficiency in terms of cost minimisation and profit maximisation in the EU to be able to face the increasing competition in these markets. The improvement in banks' performance is expected to reflect on maximising banks' shareholders wealth as the ultimate objective of banks' managers. The financial integration and globalisation and the complications in the financial markets all are environmental dynamics that further highlighted the importance of improving banks' efficiency. Given such a sophisticated environment more emphasis has been specified to the issue of controlling banking risk. The financial crisis in the mid-2000s has revealed that the role of risk is non-negligible in destabilising the banking system in the US and Europe.

The primary aim of this study was to assess and evaluate cost and profit efficiencies of the European Union banking systems using the stochastic frontier analysis (SFA) over the period 2004-2010. Using a sample of 947 commercial banks operating in the 27 EU member states, this study examined bank efficiency for four EU groups; the entire EU, the old EU countries, the new EU countries and the GIIPS countries and made comparisons between these groups. Moreover, it investigated the effect of these risks in addition to other explanatory variables including micro and macro variables on banking inefficiency. The effects of the financial crisis and the aforementioned risk variables during the crisis on bank inefficiency were also examined in this study. Finally, this study investigated the influence of bank cost and profit efficiencies, risk and the crisis on the performance of bank stocks over the period 2004-2010.

Regarding bank cost and profit efficiencies, the results showed that cost and profit efficiencies improved, on average, in the European Union banking system over the period from 2004 to 2010. In the case of cost efficiency, banks in the GIIPS countries appeared to be the most efficient banks in the EU while the new EU countries experienced the lowest level of cost efficiency in the sample. Large banks appeared to be the most cost efficient banks in the sample. All the four groups exhibited positive evolution in efficiency between 2004 and 2010 and the efficiency gap between the old and the new EU states decreased significantly, probably suggesting convergence or catching up between the two groups. Except for the new EU countries, all the other groups experienced a slight increase in the efficiency dispersion during the crisis time. Moreover, cost efficiency, on average, decreased during the crisis time for all the groups except for the new EU states. As to profit efficiency, the GIIPS countries again maintained the highest level of profit efficiency in the sample while the old EU countries experienced the lowest level of efficiency on average. The very large banks appeared to be the most profit efficient banks in the sample. All the four groups exhibited positive evolution in profit efficiency over the seven years under study and the efficiency gap between the old and the new EU countries decreased significantly. Furthermore, clear fluctuations in efficiency dispersion were noticed in the cases of the new EU countries and the GIIPS countries. The world financial crisis had a negatively stronger and more obvious effect on profit efficiency levels in all the EU groups than cost efficiency.

Concerning the determinants of bank cost and profit inefficiencies, the empirical results showed that the capital ratio had, in general, a positive effect on both cost and profit inefficiencies, while this effect shifted to negative during the crisis suggesting that better capitalised banks (with less insolvency risk) seemed to be more resistant to the crisis than less capitalised banks in terms of both cost and profit efficiencies. Loans to assets ratio (liquidity risk) negatively affected both cost and profit inefficiencies, while this effect turned to positive during the crisis time only in the case of profit inefficiency, meaning that more liquid banks outperformed their counterparts in terms of profit maximisation during the crisis. Furthermore, the ratio of non-performing loans to gross loans (credit risk) had a positive effect on cost and profit inefficiencies over the crisis and non-crisis time and this effect was more significant in the case of cost inefficiency than profit inefficiency over the crisis. This suggested that banks with lower credit risk appeared to be more cost and profit efficient over stable and non-stable economic conditions. Therefore, the results postulate that the level of bank risks mattered during the crisis time and controlling banking risks is important to protect banking performance during times of financial distress. The results also revealed that the financial crisis had a positive influence on the cost and profit inefficiencies, meaning that commercial banks' performance deteriorated during the crisis compared to the non-crisis time. Finally, using the Spearman rank order correlation, we found that cost and profit efficiencies were significantly and positively correlated with each other, meaning that the most cost efficient banks were also the most profit efficient banks.

The empirical results of the variables affecting bank stock returns in the EU showed that changes in bank cost and profit efficiencies had a significant influence on bank stock return whether the SFA-based efficiency or accounting ratio measure of efficiency was used. Compared to the accounting ratio of profit efficiency, the SFA-based efficiency has more explanatory power to variability of stock returns. In addition, profit efficiency was more informative than cost efficiency as the former explained to a larger extent the variability in stock returns than the latter. Bank size and the level of equity (insolvency risk) positively affected banks' stock returns, while credit risk and liquidity risk had no significant effect on stock returns. The world financial crisis negatively affected stock performance for the whole sample. However, the banks in the new EU countries outperformed the banks in the old EU countries in terms of stock returns during the crisis time. Finally, stock returns appeared to be significantly and positively sensitive to market risk, whereas they were found to be negatively and significantly sensitive to interest rate risk.

8.2 Policy Implications

The results of this study have various policy implications that should be considered. Regarding banks' risk, the magnitude of the negative effect of risk on banks' performance is rather augmented during the crisis time. Well-capitalised banks with less credit risk as well as banks with more liquidity appeared to perform better in terms of cost minimisation and profit maximisation during the crisis period. This suggests that maintaining high levels of risk at banks would increase the possibility of performance deterioration within European Union banking systems in times of financial distress.

Therefore, banking supervisory bodies and policy makers in the EU should put in place an early warning system that monitors the levels of banks' risk, which will help in maintaining sound and stable banking systems in Europe. This can be done by strictly supervising and forcing banks to maintain sufficient amounts of capital (and hence decrease the level of leverage) that can absorb losses caused by instability in the economic and financial environment overall. Also, banks should have reasonable liquidity in order to meet expected and unexpected obligations without facing extra costs related to sudden borrowing, this is in the case that borrowing is even attainable during credit crunch times. Banks should additionally take seriously the issue of the maturity mismatch that led to reduction in funding liquidity and contributed to the financial crisis, as argued by Brunnermeier (2009). The process of securitization, the too-big-to-fail doctrine and the high compensation schemes increased the level of credit risks and became causes of the world crisis. All these factors must be looked after by financial supervisors and policy makers so as to maintain low levels of credit risk at commercial banks and other financial institutions. After the crisis revealed the need for improving the financial regulatory system, policy makers and regulators in the EU and the world overall exerted some efforts towards this aim and a good step towards more effective and prudent supervision was the agreement to adopt of Basel III Accord in 2010-2011. Basel III aimed at enhancing capital requirements, discouraging high level of leverage, introducing better liquidity risk requirements, and developing sustainable frameworks to deal with securitisation, compensation practices, and moral hazards risks (ECB, 2010). This adoption is definitely a step in the right direction; however, to what extent the new Basel III accord can prevent similar crises from happening only the future can reveal.

Second, the study results revealed that banks in the new EU countries were, on average, less cost efficient but more profit efficient than their counterparts in the old EU countries. The less competitive, and hence more concentrated banking markets in the new EU countries might have helped banks generate higher profits compared to banks operating in highly competitive markets in the old EU states. However, and for the same reason banks in the new EU states might have experienced less pressure to decrease their costs and therefore appeared to be less cost efficient than banks in the old EU states. The results confirmed that banks operating in more concentrated markets are less cost efficient but more profit efficient compared to banks operating in less concentrated markets. There might be a convergence or catching up between the banking systems in the new and the old EU countries as the efficiency gap decreased between the two groups which might support the hypothesis of increased integration in banking markets in the EU. However, this integration can be enhanced further by increasing the level of competition in the new EU countries which in turn might impose pressure on banks there to control their costs and generate reasonable profits. The new EU countries can increase the level of competition in their banking markets by licensing for new banks to open or encouraging existing banks to open more branches as well as by making the financial regulatory environment more attractive and hence seducing and facilitating the entry of foreign banks.

Third, when investigating the determinants of bank stock returns in the EU, both cost and profit efficiencies represented using SFA measures and accounting ratio measures appeared to significantly and positively affect stock performance. This highlights the importance of increasing cost and profit efficiencies of commercial banks not only in order to have a stable banking system but also to enhance the stability of stock markets. As stock returns are considered an important indicator for bank performance, which in turn maximises the wealth of bank shareholders, policy makers and bank managers in the EU should collaborate in order to improve cost and profit efficiencies of banks and hence maximising shareholders wealth through better stock performance. The stocks of banks with less insolvency risk (with higher capital) perform better than their counterparts. This, again, highlights the issue of maintaining sufficient amounts of capital not only to have efficiently-operating banks but also to have better stock performance so as to satisfy the bank shareholders.

8.3 Limitations of the Study and Future Research

Overall, this study has improved our knowledge of the operation of the European Union banking systems by providing insights regarding bank cost and profit efficiencies, banking risks and banks' stock performance as well as the relationship between them in the presence of the world financial crisis. However, this study has limitations that might suggest and encourage potential directions for future research.

The first limitation in this study is that it only applied the stochastic frontier analysis (SFA) to measure bank cost and profit efficiencies. In spite of the advantages and the popularity of this method in the banking efficiency literature, different frontier techniques that were introduced in this study could be used along with the SFA. Particularly, it could be of interest to also use a non-parametric frontier method such as the data envelopment analysis (DEA) to the same sample commercial banks. A comparison of the empirical results generated using both frontier methods would provide a stronger support to our findings. Furthermore, such a comparison would enhance the methodological checking procedures in order for researchers and policy makers to evaluate the robustness of cost and profit efficiency levels in the banking efficiency literature.

The second shortcoming of this thesis is the time period considered for the empirical analysis. Although Hollo and Nagy (2006) shed light to some extent on bank cost and profit efficiencies in the EU before 2004, the year in which 10 new countries joined the EU, it would be interesting if the efficiency of the new EU countries would be compared for the period before 2004 (transitional period) and after this year (post-transitional period) in one study. However, because of data availability provided by the Bankscope database, such a comparison was not possible. Future research might run such comparison in case data for longer periods of time is available. Also, by the time we collected our data, we could only obtain data until the year 2010. But given that the Eurozone sovereign debt crisis persisted from late 2009 to 2012, it would be interesting to investigate the effect of this crisis on bank efficiency not only in the GIIPS countries but all over the EU which was affected somewhat by this crisis. Future research that extends the study period beyond 2010 might provide a good understanding to how the Eurozone crisis influenced banking efficiency in the GIIPS countries and other parts of the EU.

Furthermore, in this study we considered the global financial crisis to persist over the years 2007-2009. However, there is some debate about the specific time when the global financial crisis starts and ends. While we followed some studies that we mentioned earlier in this study to use the period 2007-2009 as the time of this crisis, other studies argue that the crisis took place in 2008 alone or 2008 and 2009 together. Also, and more importantly, the sovereign-debt crisis started from year 2010 meaning that the European countries might still had crisis after the year 2009. However, because the focus in this study is on the world financial crisis 2007-2009, we considered the year 2010 as post-crisis period. In addition, because we focused in this study only on commercial banks for which all control and environmental variables should be available; the sub-sample of listed commercial banks generated in Chapter 7 so as to investigate the determinants of bank stock returns was limited and fairly small. This resulted in some countries being not represented at all in some years; such as Italy and Sweden in 2004 while other countries; such as Denmark was overrepresented in the same year. Using different bank specialisations in one study could have been beneficial and generated larger sample of listed banks so that the relationship between banking efficiency and stock performance can be examined more comprehensively. Also, we refer to the idea that all listed banks in the EU member states were required to adopt the International Financial Reporting Standards (IFRS) from 2005 rather than the US Generally Accepted Accounting Principles (GAAP). Therefore, they might be some differences in the financial statements of listed banks in this study between the years 2004 and 2005.

Finally, we analysed banking risks and tried to investigate how the level of these risks might have changed before and during a crisis and how these risks might affect banking efficiency. It would be interesting to investigate whether banks in the EU have learned a lesson from the world financial crisis and the significant role bank risks played in the crisis, as proved in this thesis. This might be done by further investigating the level of bank risks in the post-crisis period from 2010 onward. This could be accompanied by examining the effect of bank risks on cost and profit efficiencies and whether they have the same influence in the post-crisis time. Moreover, future research might be carried out on the performance of bank stocks in the EU and to what extent the EU stock markets recovered from the crisis as well as to what extent bank efficiency and risk might influence stock performance.

Appendices:

Appendix 1

Cross-Sectional Cost Frontier Models:

To construct the cost frontier of best-practice firms, and therefore measure the relative cost efficiency of other firms in the sample, we need information on input prices, outputs, and total cost for firm *I*. The basic form of cost frontier, as Kumbhakar and Lovell (2000) suggest, can be written as:

$$TC_i \geq c(y_i, w_i; \beta) \quad i = 1, \dots, I, \qquad (1)$$

Where $TC_i = \sum_n w_{ni} x_{in}$ is the total costs incurred by firm i to produce outputs $y_i = (y_{1i}, \dots, y_{Mi}) \geq 0$, $w_i = (w_{1i}, \dots, w_{Ni}) > 0$ are input prices incurred by firm *i*, the deterministic cost frontier common to all firms is $c(y_i, w_i; \beta)$, and β is a vector of parameters to be estimated. The cost efficiency of firm i (CE_i) can be measured as the ratio of minimum feasible cost to actual cost:

$$CE_i = \frac{c(y_i, w_i; \beta)}{TC_i} \qquad (2)$$

It can be proved that $CE_i \leq 1$ since $TC_i \geq c(y_i, w_i; \beta)$, and the extra costs faced by firm *i* over the minimum feasible cost, expressed by the deterministic cost frontier; $c(y_i, w_i; \beta)$, is assigned to cost inefficiency. To account for random factors that might affect costs and that are out of the control of management, a random term should be added to equation (1) to attain what is called the stochastic cost frontier:

$$TC_i \geq c(y_i, w_i; \beta).\exp\{v_i\} \qquad (3)$$

As can be seen, the stochastic cost frontier $c(y_i, w_i; \beta).\exp\{v_i\}$ consists of the deterministic part $c(y_i, w_i; \beta)$ that is common to all firms and the firm-specific random part; $\exp\{v_i\}$. In this sense, equation (2) that defines cost efficiency can be re-written as:

$$CE_i = \frac{c(y_i, w_i; \beta).\exp\{v_i\}}{TC_i} \qquad (4)$$

This equation takes the environmental factors faced by each firm into account to measure cost efficiency that again takes a value of less or equal to unity; $CE_i \leq 1$.

The Single-Output Cobb-Douglas Cost Frontier:

In the log-linear Cobb-Douglas functional form the single-output cost frontier can be stated as:

$$\ln TC_i \geq \beta_0 + \beta_y \ln y_i + \sum_n \beta_n \ln w_{ni} + v_i$$

$$= \beta_0 + \beta_y \ln y_i + \sum_n \beta_n \ln w_{ni} + v_i + u_i \qquad (5)$$

Where v_i is a two-sided noise term, and u_i is a non-negative cost inefficiency term, where the two terms combine what is called the composite error term; $\varepsilon_i = v_i + u_i$. Using equation (4) to measure cost efficiency, it can be derived that $CE_i = \exp\{-\hat{u}_{\boldsymbol{i}}\}$. (6)

The JLMS point estimator, suggested by Jondrow, Lovell, Materov, and Schmidt (1982), can be used to estimate the inefficiency term u_i and substitute it in equation (6) to obtain the cost efficiency score of firm *i*. The cost frontier model defined in equation (5) can be estimated using maximum likelihood technique with the distributional assumptions:

(1) $v_i \sim iidN(0, \sigma_v^2)$
(2) $u_i \sim iidN^+(0, \sigma_u^2)$
(3) u_i and v_i are distributed independently of the regressors, and of each other[51].

[51] See Kumbhakar and Lovell (2000) for more discussion.

Appendix 2

Appendix 2a: Number of Banks and Observations in Sample for Countries between 2004 and 2010

Country	Symbol	Year							Total Observations	Number of Banks
		2004	2005	2006	2007	2008	2009	2010		
Austria	AT	22	26	29	31	30	29	22	189	39
Belgium	BE	14	16	15	12	10	10	5	82	21
Bulgaria	BG	11	15	12	17	16	16	10	97	23
Cyprus	CY	7	9	8	7	8	6	3	48	12
Czech Republic	CZ	11	15	14	13	11	12	13	89	20
Denmark	DK	36	41	44	45	42	41	32	281	53
Estonia	EE	3	3	4	4	4	4	3	25	6
Finland	FI	2	4	4	4	6	6	5	31	6
France	FR	64	73	73	70	79	73	56	488	108
Germany	DE	93	88	92	93	95	84	60	605	127
Greece *	GR	9	9	5	5	6	10	10	54	13
Hungary	HU	8	4	6	10	11	11	7	57	18
Ireland *	IE	3	7	11	11	10	10	11	63	16
Italy *	IT	6	78	77	78	81	70	57	447	106
Latvia	LV	15	18	16	18	18	18	14	117	22
Lithuania	LT	8	8	8	9	7	8	7	55	9
Luxembourg	LU	50	49	48	55	57	48	32	339	71
Malta	MT	3	3	3	4	5	5	4	27	6
Netherlands	NL	12	12	10	14	20	19	15	102	28
Poland	PL	15	15	14	19	22	21	17	123	33
Portugal *	PT	3	6	7	6	9	9	9	49	15
Romania	RO	19	21	20	21	21	18	14	134	24
Slovakia	SK	10	11	10	11	12	11	10	75	14
Slovenia	SI	11	13	13	11	12	12	9	81	15
Spain *	ES	11	35	28	28	30	34	18	184	52
Sweden	SE	13	15	12	14	16	15	11	96	17
UK	GB	35	45	49	51	47	43	42	312	73
Total Observations		494	639	632	661	685	643	496	4250	947

Notes: Underlined country names are the old EU member states, countries with no underline are the new EU member states and countries with * are the GIIPS countries.

Appendix 2b: Expected Signs of the Determinants of Banks' Inefficiency

Variables	Symbol	Description	Cost Inefficiency	Profit Inefficiency
Bank-Risk Variables				
Equity Ratio	EQ	Equity Capital over Total Assets %	- *or* +	- *or* +
Equity Ratio*Crisis	EQ_CRISIS	Equity Ratio Multiplied by World Crisis Dummy	-	-
Total Loans/Total Assets	TLTA	Total Loans over Total Assets %	+	-
Total Loans/Total Assets* Crisis	TLTA_CRISIS	Total Loans/Total Assets Multiplied by World Crisis Dummy	+	+
Non-Performing Loans/ Gross Loans	NPLTL	Non-Performing Loans over Gross Loans %	+	+
Non-Performing Loans/Gross Loans*Crisis	NPLTL_CRISIS	Non-Performing Loans/Gross Loans Multiplied by World Crisis Dummy	+	+
Other Explanatory Variables				
Size	SIZE	Log of Total Bank Assets (millions of US$)	-	-
Return on Average Assets	ROAA	Net Income over Average Total Assets %	-	-
Intermediation Ratio	INTERMED	Total Loans over Total Deposits %	-	-
Market Concentration	CONC	Sum of Total Assets of the Five Largest Banks over Total Assets of the Entire Banking System %	- *or* +	-
Inflation Rate	INFL	Annual Inflation Rate %	- *or* +	- *or* +
Nominal Interest Rate	NIR	Long-Term Government Bond Yield %	+	- *or* +
World Financial Crisis (2007-2009)	CRISIS	Dummy Variable Takes Value of 1 for Years 2007-2009, or 0 Otherwise	+	+
Country Dummy	C_DUMMY	Dummy Variable Takes Value of 1 for the Old EU Countries, and 0 Otherwise	-	- *or* +
Country Dummy*Crisis	C_CRISIS	Country Effect Dummy Multiplied by World Crisis Dummy	+	+
GIIPS _Dummy	GIIPS	Dummy Variable Takes Value of 1 for the GIIPS Countries, and 0 Otherwise	- *or* +	- *or* +
GIIPS_Dummy*Crisis	GIIPS_CRISIS	GIIPS_Country Effect Dummy Multiplied by World Crisis Dummy	- *or* +	- *or* +

Appendix 2c: Descriptive Statistics of the Determinants of Banks' Inefficiency

Variable	Obs	Mean	Std. Dev.	Min	Max
Bank Risk Variable					
EQ	4250	8.905865	7.01268	0.1	75.2
EQ_CRIS	4250	3.925027	6.311003	0	70.7
TLTA	4250	51.96917	25.33142	0.0166223	98.95178
TLTACRIS	4250	23.76728	31.41907	0	98.7997
NPLTL	4250	2.559216	5.678333	0.06	91.5
NPLCRIS	4250	1.295794	4.33265	0	91.5
Other Explanatory Variables					
SIZE	4250	8.037419	1.965823	2.995732	14.93559
ROAA	4250	0.6408684	1.888211	-32.4	21.2
INTERMED	4250	147.3651	528.1803	0.06	30433.33
CONC	4250	75.52307	14.56814	37.88	100
INFL	4250	2.567383	2.113428	-4.47994	15.4032
NIR	4250	5.631548	9.422786	2.41417	76.55
CRISIS	4250	0.451871	0.4977368	0	1
C_DUMMY	4250	0.7815957	0.4132119	0	1
C_CRISIS	4250	0.3610261	0.4803546	0	1
GIIPS	4250	0.1875735	0.3904172	0	1
GIIPSCRIS	4250	0.0884914	0.2840417	0	1

Appendix 3

Table 3a: Cost Efficiency Estimates and Evolution for EU Groups									
Country	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**Evolution %**	**Average (All)**
EU27	0.721	0.737	0.734	0.739	0.732	0.732	0.737	2.21	0.734
EU15	0.736	0.75	0.742	0.746	0.731	0.735	0.743	0.95	0.74
EU12	0.675	0.687	0.701	0.716	0.736	0.722	0.717	6.13	0.709
EUGIIPS	0.787	0.798	0.797	0.818	0.798	0.786	0.797	1.32	0.798
Eff-gap	0.061	0.063	0.041	0.03	-0.005	0.012	0.026	-56.64	0.032

Table 3b: Alternative Profit Efficiency Estimates and Evolution for EU Groups									
Country	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**Evolution %**	**Average (All)**
EU27	0.571	0.576	0.582	0.551	0.546	0.568	0.615	7.79	0.571
EU15	0.56	0.563	0.568	0.537	0.533	0.563	0.612	9.26	0.56
EU12	0.602	0.625	0.637	0.603	0.591	0.584	0.625	3.75	0.609
EUGIIPS	0.652	0.609	0.618	0.595	0.585	0.628	0.66	1.18	0.616
Eff-gap	-0.042	-0.061	-0.069	-0.066	-0.058	-0.021	-0.012	-70.57	-0.048

Appendix 4

Appendix 4a: Correlation Matrix of Environmental Variables (NPL/TL Not Included)

	SIZE	ROAA	INTERMED	EQ	EQCRIS	TLTA	TLTACRIS	CONC	INFL	NIR	CRISIS	CDUMMY	CCRISIS	GIIPS	GIIPSCRIS
SIZE	1.000														
ROAA	-0.003	1.000													
INTERMED	0.010	-0.010	1.000												
EQ	-0.391	0.097	0.023	1.000											
EQ_CRIS	-0.118	-0.034	0.027	0.458	1.000										
TLTA	0.000	-0.032	0.104	-0.031	0.003	1.000									
TLTACRIS	0.082	-0.078	0.058	-0.033	0.561	0.398	1.000								
CONC	-0.059	-0.026	0.018	0.100	0.002	0.258	0.048	1.000							
INFL	-0.122	0.050	0.002	0.068	0.063	0.047	0.082	-0.078	1.000						
NIR	-0.033	-0.002	0.000	0.012	-0.060	0.086	-0.075	-0.036	0.083	1.000					
CRISIS	0.105	-0.078	0.024	-0.028	0.490	0.023	0.571	-0.065	0.054	-0.095	1.000				
C_DUMMY	0.155	-0.019	0.018	-0.086	-0.018	-0.080	-0.007	0.014	-0.551	-0.340	0.038	1.000			
C_CRISIS	0.133	-0.062	0.028	-0.058	0.529	-0.023	0.556	-0.038	-0.217	-0.115	0.612	0.397	1.000		
GIIPS	0.152	-0.045	0.008	0.028	0.029	0.173	0.079	0.115	-0.093	-0.070	0.019	0.254	0.111	1.000	
GIIPSCRIS	0.119	-0.026	0.009	0.010	0.257	0.115	0.372	0.072	-0.090	-0.040	0.343	0.165	0.415	0.648	1.000

Appendix 4b: Correlation Matrix of Environmental Variables (NPL/TL Included)

	SIZE	ROAA	INTERMED	EQ	EQCRIS	TLTA	TLTACRIS	NPLTL	NPLTLCRIS	OFFBSTA	CONC	INFL	NIR	CRISIS	CDUMMY	CCRISIS	GIIPS	GIIPSCRIS
SIZE	1.000																	
ROAA	-0.003	1.000																
INTERMED	0.010	-0.010	1.000															
EQ	-0.391	0.097	0.023	1.000														
EQ_CRIS	-0.118	-0.034	0.027	0.458	1.000													
TLTA	0.000	-0.032	0.104	-0.031	0.003	1.000												
TLTACRIS	0.082	-0.078	0.058	-0.033	0.561	0.398	1.000											
NPLTL	0.121	-0.114	0.223	0.331	-0.113	0.241	0.234	1.000										
NPLCRIS	0.025	-0.130	-0.004	0.001	0.238	0.071	0.325	0.543	1.000									
OFFBS_TA	0.021	0.025	0.006	0.017	0.000	-0.015	-0.009	-0.024	-0.024	1.000								
CONC	-0.059	-0.026	0.018	0.100	0.002	0.258	0.048	-0.003	-0.039	-0.093	1.000							
INFL	-0.122	0.050	0.002	0.068	0.063	0.047	0.082	0.026	0.077	-0.007	-0.078	1.000						
NIR	-0.033	-0.002	0.000	0.012	-0.060	0.086	-0.075	0.070	-0.003	0.001	-0.036	0.083	1.000					
CRISIS	0.105	-0.078	0.024	-0.028	0.490	0.023	0.571	0.049	0.329	-0.008	-0.065	0.054	-0.095	1.000				
C_DUMMY	0.155	-0.019	0.018	-0.086	-0.018	-0.080	-0.007	-0.213	-0.135	-0.008	0.014	-0.551	-0.340	0.038	1.000			
C_CRISIS	0.133	-0.062	0.028	-0.058	0.529	-0.023	0.556	-0.056	0.145	-0.001	-0.038	-0.217	-0.115	0.612	0.397	1.000		
GIIPS	0.152	-0.045	0.008	0.028	0.029	0.173	0.079	0.132	0.078	-0.031	0.115	-0.093	-0.070	0.019	0.254	0.111	1.000	
GIIPSCRIS	0.119	-0.026	0.009	0.010	0.257	0.115	0.372	0.092	0.212	-0.025	0.072	-0.090	-0.040	0.343	0.165	0.415	0.648	1.000

Appendix 5

Appendix 5a: Number of Banks and Observations in Sample for Each EU Country between 2005 and 2010

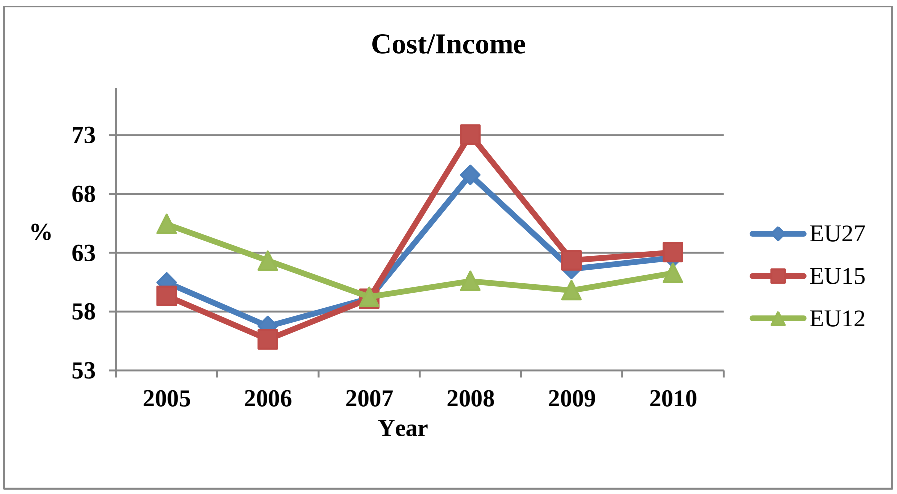
Country	Symbol	Year						Total	Number of
		2005	2006	2007	2008	2009	2010	Observations	Banks
Austria	**AT**	1	0	0	1	2	2	6	3
Bulgaria	**BG**	0	0	0	2	3	2	7	3
Cyprus	**CY**	0	0	0	1	1	1	3	2
Czech Republic	**CZ**	0	1	1	1	1	1	5	1
Denmark	**DK**	27	32	32	28	27	26	172	38
Finland	**FI**	1	1	1	1	1	1	6	1
France	**FR**	2	4	3	5	5	4	23	6
Germany	**DE**	6	7	9	11	10	10	53	12
Greece *	**GR**	4	2	2	3	5	6	22	8
Ireland *	**IE**	1	2	4	4	2	2	15	4
Italy *	**IT**	0	5	5	7	9	6	32	10
Latvia	**LV**	0	1	1	2	2	1	7	2
Lithuania	**LT**	0	0	4	3	3	3	13	4
Malta	**MT**	2	2	2	3	3	2	14	4
Netherlands	**NL**	1	1	1	1	1	1	6	2
Poland	**PL**	4	4	6	11	11	11	47	13
Portugal *	**PT**	1	2	2	2	2	1	10	2
Romania	**RO**	2	2	2	2	2	2	12	2
Slovakia	**SK**	2	3	3	2	2	1	13	3
Slovenia	**SI**	1	1	1	1	2	1	7	2
Spain *	**ES**	3	12	13	9	8	7	52	14
Sweden	**SE**	0	2	2	2	2	2	10	2
UK	**GB**	1	0	2	0	0	0	3	3
Total Observations		59	84	96	102	104	93	538	141

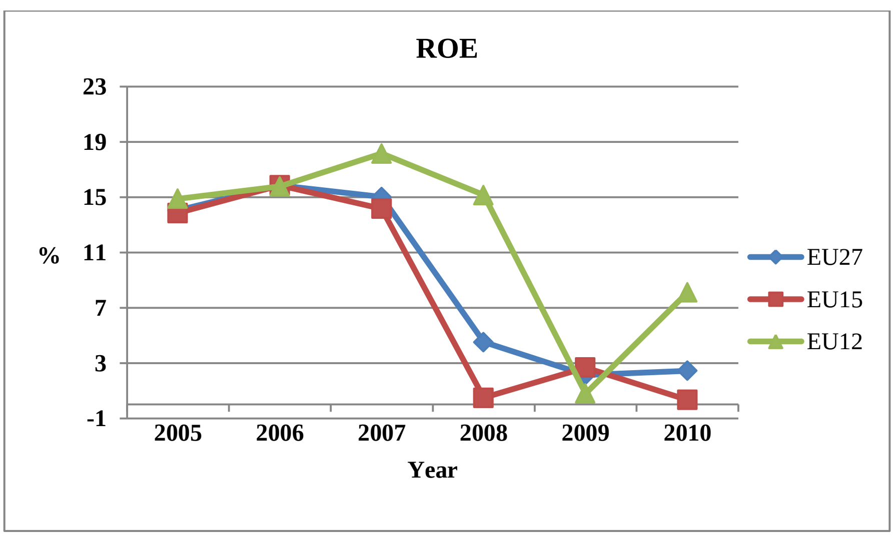
Notes: Underlined country names are the old EU member states, countries with no underline are the new EU member states and countries with * are the GIIPS countries.

Appendix 5b

Descriptive Statistics of Cost/Income and ROE Ratios						
Country Sample	**Variables**	***Mean***	***S.D.***	***Min.***	***Max.***	***Obs.***
EU27	C/I	61.972	17.990	1.46	185.39	538
	ROE	8.377	15.369	-129.58	48.85	538
EU15	C/I	62.294	18.927	1.46	185.39	410
	ROE	7.582	15.748	-129.58	48.85	410
EU12	C/I	60.939	14.603	17.09	109.21	128
	ROE	10.926	13.837	-63.76	42.57	128

Note: C/I is cost to income ratio, ROE is return on equity, S.D.is standard deviation, Max.is the maximum value, Min.is the minimum value, Obs is number of observations.





Appendix 5c: Expected Signs of the Determinants of Bank Stock Returns

Variable	Symbol	Description	Effect on Stock Return
Cost Efficiency	**CE**	Annual Percentage Change in Cost Efficiency	+
Cost/Income	**C/I**	Annual Percentage Change in Cost/Income Ratio	-
Profit Efficiency	**PE**	Annual Percentage Change in Profit Efficiency	+
Return on Equity	**ROE**	Annual Percentage Change in ROE Ratio	+
Size	**SIZE**	Annual Percentage Change in Total Assets	*- or +*
Equity Ratio	**EQ**	Annual Percentage Change in Equity/Total Assets	*- or +*
Total Loans/Total Assets	**TLTA**	Annual Percentage Change in Total Loans/Total Assets	-
Non-Performing Loans/ Gross Loans	**NPLTL**	Annual Percentage Change in Non-Performing Loans/ Gross Loans	-
World Financial Crisis (2007-2009)	**CRISIS**	Dummy Variable Takes Value of 1 for the Years 2007-2009, or 0 Otherwise	-
Country Dummy	**C_DUMMY**	Dummy Variable Takes Value of 1 for the Old EU Countries, or 0 Otherwise	*- or +*
Country Dummy*Crisis	**C_CRISIS**	Country Dummy Multiplied by Crisis Dummy	-
Market Return	**MR**	Annual Return on Market Index	+
Nominal Interest Rate	**NIR**	Annual Relative Change in Long-Term Government Bond Yield	*- or +*

Appendix 5d: Stock Returns Correlations:

	R	**MR**
R	1	
MR	0.6039*	1

* indicates 1% significance level.

Appendix 6

Appendix 6a: Model (A) Regression Diagnostic Tests of STATA for Model (I)

Appendix 6a.1 Variance Inflation Factors

Variable	VIF	1/VIF
C_CRISIS	5.57	0.179619
CRISIS	4.46	0.223990
C_DUMMY	2.31	0.432916
CE	1.07	0.935755
EQ	1.05	0.954504
SIZE	1.04	0.958942
Mean VIF	2.58	

Appendix 6a.2 Breusch-Pagan/Cook-Weisberg Test for Heteroskedasticity

```
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of CASR

         chi2(1)      =     1.13
         Prob > chi2  =   0.2868
```

Appendix 6a.3 Wooldridge Test for Autocorrelation in Panel Data

```
Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
    F(  1,      98) =      0.982
           Prob > F =      0.3241
```

Appendix 6a.4 Hausman Test

	Coefficients (b) fe	(B) re	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
CE	-1.118107	-.7447698	-.373337	.2065682
SIZE	.2671845	.320165	-.0529805	.0680074
EQ	.5461016	.5388809	.0072207	.0419825
CRISIS	.0501691	-.0023407	.0525097	.0426874
C_CRISIS	-.2882035	-.2290447	-.0591588	.0484683

```
                b = consistent under Ho and Ha; obtained from xtreg
 B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test:  Ho:  difference in coefficients not systematic

              chi2(5) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                      =        4.72
            Prob>chi2 =      0.4508
```

Appendix 6b: Model (A) Regression Diagnostic Tests of STATA for Model (II)

Appendix 6b.1 Variance Inflation Factors

Variable	VIF	1/VIF
C_CRISIS	5.40	0.185323
CRISIS	4.30	0.232473
C_DUMMY	2.31	0.433212
EQ	1.07	0.934228
CI	1.07	0.934748
SIZE	1.07	0.935906
Mean VIF	2.54	

Appendix 6b.2 Breusch-Pagan/Cook-Weisberg Test for Heteroskedasticity

```
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
        Ho: Constant variance
        Variables: fitted values of CASR

        chi2(1)      =     8.20
        Prob > chi2  =   0.0042
```

Appendix 6b.3 Wooldridge Test for Autocorrelation in Panel Data

```
Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
    F(  1,      98) =      0.918
           Prob > F =      0.3404
```

Appendix 6b.4 Hausman Test

	Coefficients (b) fe	(B) re	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
CI	-.7165126	-.5912543	-.1252583	.0484796
SIZE	.1298512	.2087653	-.0789141	.0628072
EQ	.4569052	.4526574	.0042478	.0377799
CRISIS	.0325842	-.0096613	.0422455	.0374619
C_CRISIS	-.2248541	-.1835484	-.0413057	.04202

```
                    b = consistent under Ho and Ha; obtained from xtreg
     B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test:  Ho:  difference in coefficients not systematic

             chi2(5) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                     =        8.62
           Prob>chi2 =      0.1253
```

Appendix 6c: Model (A) Regression Diagnostic Tests of STATA for Model (III)

Appendix 6c.1 Variance Inflation Factors

Variable	VIF	1/VIF
C_CRISIS	5.45	0.183605
CRISIS	4.61	0.216907
C_DUMMY	2.34	0.427132
PE	1.20	0.835861
SIZE	1.07	0.934448
EQ	1.04	0.958830
Mean VIF	2.62	

Appendix 6c.2 Breusch-Pagan/Cook-Weisberg Test for Heteroskedasticity

```
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
        Ho: Constant variance
        Variables: fitted values of CASR

        chi2(1)      =     6.35
        Prob > chi2  =   0.0117
```

Appendix 6c.3 Wooldridge Test for Autocorrelation in Panel Data

```
Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
    F(  1,      98) =      1.506
           Prob > F =      0.2227
```

Appendix 6c.4 Hausman Test

	Coefficients (b) fe	(B) re	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
PE	.6559583	.7493524	-.0933941	.2144413
SIZE	.291924	.3593704	-.0674464	.0702085
EQ	.5189983	.5196699	-.0006716	.0431439
CRISIS	.0539911	.0199035	.0340876	.0476641
C_CRISIS	-.2552257	-.2185322	-.0366934	.0489655

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test: Ho: difference in coefficients not systematic

chi2(5) = (b-B)'[(V_b-V_B)^(-1)](b-B)
= 1.84
Prob>chi2 = 0.8704

Appendix 6d: Model (A) Regression Diagnostic Tests of STATA for Model (IV)

Appendix 6d.1 Variance Inflation Factors

Variable	VIF	1/VIF
C_CRISIS	5.40	0.185193
CRISIS	4.29	0.232985
C_DUMMY	2.31	0.432216
EQ	1.06	0.942101
SIZE	1.04	0.958813
ROE	1.02	0.976873
Mean VIF	2.52	

Appendix 6d.2 Breusch-Pagan/Cook-Weisberg Test for Heteroskedasticity

```
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of CASR

         chi2(1)      =     0.65
         Prob > chi2  =   0.4186
```

Appendix 6d.3 Wooldridge Test for Autocorrelation in Panel Data

```
Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
    F(  1,      98) =      1.221
           Prob > F =      0.2719
```

Appendix 6d.4 Hausman Test

	—— Coefficients ——			
	(b) fe	(B) re	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
ROE	-6.69e-06	.0001306	-.0001372	.0002568
SIZE	.2553244	.3135447	-.0582203	.0704639
EQ	.5285856	.5243346	.004251	.0430843
CRISIS	-.0006079	-.0345954	.0339875	.0426163
C_CRISIS	-.2325727	-.1965999	-.0359727	.0480581

```
                          b = consistent under Ho and Ha; obtained from xtreg
           B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(5) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =        2.06
                Prob>chi2 =      0.8406
```

Appendix 6e: Model (B) Regression Diagnostic Tests of STATA

Appendix 6e.1 Variance Inflation Factors

Variable	VIF	1/VIF
MR	1.00	0.997198
NIR	1.00	0.997198
Mean VIF	1.00	

Appendix 6e.2 Breusch-Pagan/Cook-Weisberg Test for Heteroskedasticity

```
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
        Ho: Constant variance
        Variables: fitted values of CASR

        chi2(1)      =    42.94
        Prob > chi2  =   0.0000
```

Appendix 6e.3 Wooldridge Test for Autocorrelation in Panel Data

```
Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
    F(  1,      98) =      6.985
           Prob > F =      0.0096
```

Appendix 6e.4 Hausman Test

	Coefficients (b) fe	(B) re	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
MR	.7215619	.6886621	.0328998	.0144906
NIR	-.1425726	-.1991586	.056586	.0471273

```
                  b = consistent under Ho and Ha; obtained from xtreg
   B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test:  Ho:  difference in coefficients not systematic

              chi2(2) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                      =        7.01
            Prob>chi2 =      0.0300
```

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