Essays on the Risk and Efficiency of the banks

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Abstract

This thesis provides an in-depth discussion on the risk and efficiency of the banks. The thesis consists of three major empirical chapters.Chapter 1 is an introduction to the topic where backgrounds, motivations and contributions of the thesis are discussed.

Chapter 2 examines the role of the European Banking Authority(EBA)'s capital exercise and technical efficiency of the banks.In October 2011, the European Banking Authority (EBA), the institution charged with setting harmonised supervisory standards for banks in EU member states, announced that major European banking groups would have to increase their core tier 1 capital ratios to 9 percent of their risk-weighted assets by June 2012 (EBA, 2011b).Using a sample of 194 banks from 15 EU countries and bootstrap data envelopment analysis (DEA) to provide evidence on the impact of EBA's capital exercise on banks' efficiency.In the first stage of the analysis, we measure the efficiency by employing Boostrap DEA. We then use Double Bootstrap Truncated regression to investigate the impact of the capital exercise on banks' technical efficiency. We estimate several specifications while controlling for bank-specific attributes and country-level characteristics accounting for macroeconomic conditions, financial development and market structure. The results indicate that EBA's capital exercise came, as a shock for the banks would be contributing towards making the banks more stable.It would be preventing banks from excessive risk-taking activities. Furthermore,it would be allowing the banks to withstand the financial distress and contributing to banks becoming less prone to the systemic risk. The study finds that the capital requirements would be creating favourable economic conditions, which would be affecting the extent, depth, and quality of financial intermediation and banking services.

Chapter 3 provides a comprehensive analysis of the risk measures on the

cost efficiency of the banks.The financial crisis revealed the problems in the banking sector for supervisors and other stakeholders in identifying and comparing the bank's information across different jurisdictions. The Basel Committee found that there are no consistent international standards for categorising problem loans. This chapter looks into the role of the harmonised definition of Non-Performing Exposures and Funding Liquidity Risk on the cost efficiency of the banks.This chapter looks into the marginal effects of the risk measures on cost efficiency. Also, the chapter investigates the marginal effects of risk measures on cost efficiency over time and across different regions. The heteroscedastic stochastic frontier model is used for the estimation, which will allow finding the effect of each risk measure on the mean and variance of the cost efficiency.The results indicate Funding Liquidity Risk has a positive effect on the mean and the variance on the inefficiency effect. This means a bank with a higher Funding Liquidity Risk will have a lower and more varied cost efficiency. Non-Performing Exposures have a significantly positive effect on the mean and variance of the inefficiency effect. The study compares average cost efficiency and marginal effects of the risk measures on the mean and variance across the groups sorted by the criteria variables. The results indicate that there are non-linear effects of some of the risk factors such as Funding Liquidity Risk and Non-Performing Exposures on the mean and variance of the inefficiency effect.

Chapter 4 investigates into the role of Cross-Border Exposures and Liquidity Shocks on the technical efficiency of the banks.Using a sample of 1931 banks in 15 countries in Europe, the impact of cross-border banking, i.e., geographical diversification, on individual banks with liquidity shock in relation to the financial development of the home country. For measuring the technical efficiency, Weighted Russell Distance Directional Model (WRDDM) is used.The results indicate that the changes in the technical efficiency of the banks facing liquidity shocks are more unstable. The technical efficiency of the banks facing Liquidity Shocks is much lower during the Global Financial Crisis. The technical efficiency of the banks not facing liquidity shock is more similar to the average technical efficiency of the banks. The decline in the cross-border exposures was witnessed with a decline in efficiency. However, the decline was minimum in the domestic exposures. Following this, Honore's Tobit Estimator

results provide evidence of the cross-border exposures with liquidity shock on the efficiency of the banks in relation to the financial development of the home country. The results indicate that banks are more likely to invest in countries with similar levels of financial development. By investing in such countries, the bank can improve its technical efficiency. However, in countries with high financial development, the banks improve efficiency by reducing exposures from countries with lower financial development. The results indicate that the role of financial development and cross-border exposures play in the efficiency of the banks.

Chapter 5 puts together the main findings from the three essays and presents the concluding remarks.

Contents

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Declaration

I declare that, except where explicit reference is made to the contribution of others,this dissertation is the result of my own work and has not been submitted for any other degree at the University of Glasgow or any other institution.

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List of Abbreviations

AE ..... Allocative Efficiency

BIS ..... Bank of International Settlements

CEB ..... Capital Exercise Banks

CEE ..... Central and Eastern European

CESSE ..... Central,European and South Eastern European

C&I ..... Commercial and Industrial

CDS ..... Credit Default Swap

CRS ..... Constant Returns to Scale

DEA ..... Data Envelopment Analysis

DFA ..... Distribution Free Approach

DMU ..... Decision-Making Unit

EBA ..... European Banking Authority

ECB ..... European Central Bank

EMEs ..... Emerging Market Economies

EU ..... European Union

GDP ..... Gross Domestic Product

GFC ..... Global Financial Crisis

IMF ..... International Monetary Fund

MBS ..... Mortgage-Backed Securities

MENA ..... Middle East and North Africa

NPEs ..... Non-Performing Exposures

NPLs ..... Non-Performing Loans

NSFR ..... Net Stable Funding Ratio

OECD ..... Organisation for Economic Co-operation and Development

OTE ..... Overall Technical Efficiency

PTE ..... Pure Technical Efficiency

ROA ..... Returns on Assets

ROE ..... Returns on Equity

RWA ..... Risk-Weighted Asset

SE ..... Scale Efficiency

SFA ..... Stochastic Frontier Analysis

TE ..... Technical Efficiency

TFA ..... Thick Frontier Approach

QE ..... Quantitative Easing

VRS ..... Variable Returns to Scale

WRDDM .... Weighted Russell Directional Distance Model

Chapter 1

Introduction

1.1 Background and Motivation

Over the years, Bank efficiency has been on the topmost research agenda. The reasons behind the increase in bank efficiency research are due to the changes in the regulatory and operating environment which contributes to banks becoming more concerned about controlling their costs while optimising revenues(Chortareas et al., 2013).Efficiency in simple terms can be related to how best a bank makes use of all available resources by transforming them into the desired outputs.Efficiency for the bank can be defined as the maximum amount of output that will be produced for a certain amount of input.Based on this definition, efficiency can be viewed as a dimension of bank performance.For example, a bank is doing well if it is efficient in its operation.Efficiency can be further observed in terms of the real quantity of output produced or in terms of cost incurred during the production of a given amount of output.This leads to two types of efficiency: technical efficiency and cost efficiency. Technical efficiency refers to the ability of optimal utilisation of available resources either by producing maximum output for a given input bundle or by using minimum inputs to produce a given output.Cost efficiency measures how close a bank's costs to the minimum possible costs of a best-practise bank that produce the same bundle of outputs using the same bundle of inputs under the same conditions(Berger et al., 1997).

Efficiency can be nurtured by a conducive environment that permits the banks to make the best decision regarding the best combination of inputs to be used or the appropriate output mix.In turn,the banking environment is

influenced by the measures introduced and taken by the authority,for example,financial liberalisation.The focus of efficiency research in developed countries has been on the implications of efficiency results for financial institutions in the areas of government policy, such as deregulation, bank failure, merger and acquisition, and so on.The estimated efficiency results are regressed against a set of variables to identify possible factors that explain the differences in performance across financial institutions.Empirical studies have reached no agreement on the sources of the measured inefficiency differences.During the last decade, there has been numerous banking reforms in developing and transition economies.As a result,bank efficiency in these countries has received considerable attention.These reforms generally starts with financial liberalisation and deregulation,followed by ownership reform through privatisation usually in the forms of foreign ownership participation and/or going public.Therefore,efficiency studies have focused on examining the effects of various reforms on bank performance.

Financial stability is important for sound economic growth.It is also considered as a precondition for conducting effective economic policy.While, a stable and strong macroeconomic setting is one of the cornerstones of the financial stability.It is important to recognise the primary function of the financial system in facilitating the deployment and allocation of economic resources spatially and timely. However, in uncertain economic conditions, the financial system might fail to harmonise with the changes in the financial environment(Pasiouras et al., 2009).Therefore,since the onset of the global financial crisis,we have increasingly heard about the need for reforms in the financial system to enhance financial stability and resolve the crisis.Indeed,the reforms in the financial system are not entirely new, despite the wave of new reforms in the aftermath of the recent global financial crisis.Historically,shocks in the financial market have called for reforms in the financial system.For example,the Latin American debt crisis and the Asian financial crisis, though the success of these reforms is questionable due to the recurrence and breadth of such crises.Undoubtedly,the primary functions of the financial system have always essentially been the same in all the countries, from West to East.However,there are sizeable differences that include variations in cultural, political,and historical backgrounds.Additionally, variations exist in the institutional mechanisms

through which the reforms are applied.Although,there is substantial and varied evidence on the role of the financial system in shaping economic development.There are serious shortcomings due to the differences across countries based on the quality of financial information,soundness of corporate governance,mechanism of diversified risk, and facilitation of trade.These differences might impede any reform vision in the financial system(Merton, 1990).Therefore, there is a need to develop benchmark financial systems across the world for evaluating financial soundness and economic performance.This might provide a clear picture of financial conditions in each country, especially in a financial environment of rapid changes and increased movement towards global connections among different financial systems across the globe.

This thesis brings together several quantitative solutions to bank efficiency through three empirical studies.The thesis adds to the literature on bank efficiency.Shocks and reforms in the banking sector play a significant role in bank efficiency.During the Global Financial Crisis,the aggregate liquidity shock is associated with the increasing volatility of asset prices with aggravated concerns over counterparty risk,liquidity risk and market conditions.This resulted in disruptions in the interbank market(Gorton and Metrick, 2012).Such shocks impact the efficiency of the bank.Bank inefficiencies could have direct implications for the social welfare in the form of deadweight social costs(Chortareas et al., 2013).The inefficient banks would price their output above the marginal social cost which results in achieving higher profits.In the aftermath of the recent crisis, achieving higher efficiency has become the most significant factor for the survival of the banks.These investigations can provide valuable information for policymakers and regulators in the future.

1.2 Contribution and Structure

In light of the motivation which is outlined above, this thesis contributed to the field of bank efficiency by exploring new aspects of shocks and reforms in the banking sector. These applications are presented in three self-contained chapters(chapters 2-4). All chapters employ either parametric or non-parametric technique for measuring the efficiency of the bank. These chapters aim to provide an analysis of the shocks and reforms in the banking sector on bank

efficiency.The results contribute to the growing literature on the importance of the shocks and reforms in the banking sector.

Chapter 2 examines the role of the European Banking Authority(EBA)'s Capital Exercise on the technical efficiency of the banks. In October 2011, EBA announced that major European banking groups would have to increase their core tier 1 capital ratios to 9 percent of their risk-weighted assets by June 2012(EBA, 2011b). This announcement came largely as a surprise, as EBA had just conducted rigorous stress tests in the summer of 2011 and had already released detailed information on the exposure of European banks to sovereign risk.Most of the studies have focused on the role of the Basel Accord on the efficiency of the banks.Basel III permitted banks to have a transition period before the regulations are fully implemented (BIS, 2011b). This allows the banks to have time to make the necessary time to make the adjustments without affecting their efficiency.The new required ratio by the EBA was higher than that planned under the transition to Basel III.Furthermore,it was explicitly not related to the level of risks of any particular banking group, but rather to ensure that all large European banks accumulated sufficient capital cushions to withstand further deterioration in the sovereign debt crisis. The horizon set by the EBA to meet the higher required was shorter compared to Basel III process. This makes the case for the observed change in lending over the period was a result of the capital requirement shock. All of these elements reflect that the capital exercise comes close to a natural experiment and providing a rare opportunity to observe an exogenous regulatory shock to bank capital.

Using a sample of 194 banks from 15 EU countries and Bootrap data envelopment analysis (DEA) to provide evidence on the impact of EBA's capital exercise on banks' efficiency. In the first stage of the analysis, we measure efficiency by employing Bootstrap DEA. We then use Double Bootstrap Truncated regression to investigate the impact of capital exercise on banks' technical efficiency.The results of DEA indicate that the average bank in the sample could improve its technical efficiency by 52.47% after the capital shock. Before the capital shock, it was 50.7%. Following this, the Double Bootstrap Truncated regression results provide evidence of the factors which determine the efficiency of the banks before and after the announcement has been made.

For the bank-specific characteristics, after the announcement, it is found that Non-Performing Loans, Return on Equity and Loan Activity of the bank are statistically significant and have a negative impact on the efficiency of the bank. While the capital of the bank has a statistically positive impact on efficiency. When taking macroeconomic condition into account, it is found that after the announcement Capital of the bank is statistically significant and has a positive impact on the efficiency of the bank and Return on Equity and Loan Activity have a negative impact. While the real GDP growth has a statistically positive impact on the efficiency of the bank. When controlling for the financial development, the size of the bank, the size of the market and the activity in the banking sector are significant and have a positive impact on the efficiency and Return on Equity has a negative impact. When controlling for the market structure, the loan activity, return on equity and non-performing loans have a significant and negative relationship with the efficiency. Finally, controlling for all the factors, the loan activity, return on equity and market concentration has a statistically significant and negative impact while financial development and real GDP growth have a statistically significant and positive impact on the efficiency.

The stricter capital regulations by EBA would only be improving the efficiency of the banks if the regulatory screening ability is low. When the capital regulations are placed, the banks are looking to substitute the loans with alternative forms of assets. The banks are looking to for different asset portfolios which would be generating better returns and requires the different resources to be managed. The results indicate that the capital requirement by EBA which came as a shock for the banks would be contributing towards making the banks more stable. It would be preventing banks from excessive risk-taking activities. Furthermore, it would be allowing the banks to withstand financial distress. Although, the capital requirements would not be a highly significant benefit for the efficiency gains. But, it would be creating favourable economic conditions which would affect the extent, depth and quality of financial intermediation and banking services.

Chapter 3 provides a comprehensive analysis of the risk measures on the cost efficiency of the banks. The Basel Committee found that there are no consistent international standards for categorising problem loans.Banks used

different methodologies and assumptions for valuations, provisioning and risk weightings, increasing opacity and reducing comparability for end-users (BIS, 2016). The definition of Non-Performing Exposures (NPEs) introduces harmonised criteria for categorising loans and debt securities that are centred on delinquency status (90 days past due) or the unlikeliness of repayment (BIS, 2016). The NPEs ratio is defined as the sum of outstanding nonperforming loans, advances and debt securities divided by all gross carrying amounts of loans, advances and debt securities. NPEs is the widest concept as it includes loans, debt securities and certain off-balance sheet exposures, but may exclude certain asset classes, such as foreclosed collateral. Liquidity risk has been recognised as a significant threat to financial institutions management and financial system stability. Generally, banks are required to maintain a liquidity buffer for managing liquidity risk and to insure against liquidity shocks.Hong et al. (2014) showed that systematic liquidity risk was an important contributor to bank failures occurring over 2009–2010 in the aftermath of the crisis. Furthermore, they found that liquidity risk could lead to bank failures through systematic and idiosyncratic channels. The theoretical predictions of Acharya and Naqvi (2012) and Wagner (2007) on the implications of short-term liquidity for bank risk-taking and bank stability suggest that the high levels of asset liquidity could potentially increase bank risk. Also, it requires further attention because of the significant welfare costs which risky banks may pose as witnessed in the recent crisis. Deposits shield the banks from bank run risk. Banks with higher deposits have less funding liquidity risk which reduces market discipline and leads to higher risk-taking by banks.Keeley (1990) found that deposit insurance creates a moral hazard for excessive risk-taking by banks in response to increase in deposits at the cost of the deposit insurer.

Using a sample of 2630 banks in 6 different global regions from 2010 to 2018, this study investigates the impact of the NPEs and Funding Liquidity Risk on the Cost Efficiency of the banks. To conduct a comprehensive analysis of the effects of NPEs, Funding Liquidity Risk and Liquidity Risk on the efficiency of the banks. To analyse the role of NPEs and Funding Liquidity Risk on cost efficiency, the study adopts the heteroscedastic stochastic frontier model in the estimation. This allows us to specify both the mean and variance of the inefficiency instability and investigate the non-monotonic effects on efficiency.

Furthermore, this chapter looks into the marginal effects of the risk measures on cost efficiency. Also, the chapter investigates the marginal effects on risk measures on the cost efficiency over time and across different regions.

The results indicate Funding Liquidity Risk has a positive effect on the mean and the variance on the inefficiency effect. This means a bank with a higher Funding Liquidity Risk will have a lower and more varied cost efficiency. Liquidity Risk has a significantly positive effect on the inefficiency effect. This indicates that an increase in Liquidity Risk lowers the profitability of the bank, which pushes down the cost efficiency of the bank and increases the fluctuation of the cost efficiency. Additionally, NPEs has a significantly positive effect on the mean and variance of the inefficiency effect.

The chapter compares average cost efficiency and marginal effects of the risk measures on the mean and variance across the groups sorted by the criteria variables. The results indicate that there are non-linear effects of some of the risk factors such as Funding Liquidity Risk and NPEs on the mean and variance of the inefficiency effect. However, for Liquidity Risk, the marginal effects indicate a non-monotonic effect. The effects of the risk measures are not consistent over time. For Funding Liquidity Risk, the marginal effect on mean is very high in 2011. After 2011, the effect starts declining until 2016. However, from 2017 onwards, the effect has again started increasing. The marginal effect shows the negative effect on cost efficiency. The marginal effect on variance has both a negative and positive effect on the cost efficiency over the years. For Non-Performing Exposures, The marginal effect on mean has a positive effect on the cost efficiency and the marginal effect on variance shows inverse U-shape like pattern. For Liquidity Risk, the marginal effect on mean shows U-shape pattern and variance has a negative effect on the cost efficiency.

The study investigated the marginal effects of how these risk measures affect both the level and variability of the inefficiency effect across six different global regions.For Funding Liquidity Risk, the marginal effects on the mean of the inefficiency effect of the banks in Asia-Pacific, Latin America and the Caribbean , Middle East, and the United States and Canada show a non-monotonic pattern. The marginal effects on variability of the inefficiency effect for Latin America, the Middle East, and the United States and Canada reveal a non-monotonic pattern. In these regions, the banks in the lowest group

have a negative variability in the lowest group and turn positive in the middle and highest groups. For Liquidity Risk, The marginal effects on the mean in Europe show a non-monotonic pattern. It shows a negative inefficiency effect on the low and middle groups whereas a positive inefficiency effect on the highest group. The marginal effects on the variability across on the groups in Europe is positive and shows a monotonic effect. This reveals that the cost efficiency is more varied among the banks in Europe. For Non-Performing Exposures, marginal effects on the mean of the inefficiency effect across all the regions reveals a positive inefficiency effect. On average across the groups, Latin America and Caribbean has the highest positive inefficiency impact. The marginal effects on variability on the inefficiency effect increases as we move along the groups.The lowest group has the lowest variability, this increase as we move to middle and highest groups.

The study provides an in-depth analysis of the risk measures.The recent crisis showed how inconsistent international standards for categorising problem loans and high funding liquidity risk proved to be a major problem for the banks.This investigation will be useful for the regulators and policymakers.As an increase in the different risk measures have different impact across the bank's efficiency in different regions.The results will be useful for the regulators and policymakers.The results will help in shaping new regulations which will be preventing the bank from excessive risk-taking.Additionally,the results show how the changes in the risk measures impacts the cost efficiency.

Chapter 4 investigates into the role of Cross-Border Exposures and Liquidity Shocks on the Technical Efficiency of the banks. During the crisis, the banks decreased their local lending and their cross-border lending (Takáts, 2010) and (Herrmann and Mihaljek, 2013). De Haas et al. (2011) found that the reduction in cross-border lending is limited for the banks which are geographically closer to the borrower and have a local office or strong relations with the local banks. The effects on the cross border lending depend on the interaction of borrower's demand and lender's supply. This chapter investigates the impact of cross-border banking, i.e., geographical diversification, on individual banks with liquidity shock in relation to the financial development of the home country. Generally, diversification has the potential to reduce risk (Markowitz, 1959). There are opposite views on whether geographical diversi-

fication is beneficial for banks.Levy and Sarnat (1970) found that geographical diversification could generate positive effects, as there is a non-perfect correlation across country-specific risks. Therefore, resulting in risk reduction in an internationally diversified portfolio. However,Winton (1999) argues that geographical diversification is not always beneficial. For example, when banks have loans with high downside risks or when banks expand into sectors where they have little expertise. Also, the further a bank away from its home country, the more difficult it may be to manage.

To analyse the impact of the cross border banking with liquidity shock on the efficiency scores estimated by Weighted Russell Directional Distance Model by using sub-samples based on the financial development of the home country. Using a sample of 1931 banks in 15 countries in Europe, the chapter examines the role of Cross-Border Exposures and Liquidity Shock on Technical Efficiency of the banks.

The results indicate that the changes in the technical efficiency of the banks facing liquidity shocks are more unstable. The technical efficiency of the banks facing Liquidity Shocks is much lower during the Global Financial Crisis. The technical efficiency of the banks not facing liquidity shock is more similar to the average technical efficiency of the banks. The decline in the cross-border exposures was witnessed with a decline in efficiency. But, the decline was minimum in the domestic exposures. This reflects the significance of the cross-border exposures on the efficiency of the banks. Following this, Honore's Tobit Estimator results provide evidence of the cross-border exposures with liquidity shock on the efficiency of the banks in relation to the financial development of the home country. The results indicate that banks are more likely to invest in countries with similar levels of financial development. By investing in such countries, the bank can improve its technical efficiency. However, in countries with high financial development, the banks improve efficiency by reducing exposures from countries with lower financial development. The results indicate that the role of financial development and cross-border exposures play in the efficiency of the banks.

The results of the study are significant for the policymakers and the banks.Most of the banks have increased cross-border exposures over the years. The financial integration has fostered cross-border banking.Cross-border banking pro-

vides the banks with an opportunity of diversification. The diversification is risk-reducing. With favourable economic conditions in the foreign country, the bank would be more inclined towards increasing their cross-border exposures. Moreover, investing in a foreign country with a similar level of financial development allows the bank to improve and have better returns. It allows the bank to manage their resources better. The cross-border exposures from favourable country contribute towards an increase in the efficiency of the banks. The bank facing liquidity shock would be reducing the cross-border exposures from regions with less favourable economic conditions. The barriers to cross-border banking would discourage the banks towards cross-border activities. These barriers may be in terms of the financial development of a foreign country. This may hurt the efficiency of the banks.

Financial stability is important for sound economic growth.It is also considered as a precondition for conducting effective economic policy.While, a stable and strong macroeconomic setting is one of the cornerstones of the financial stability.In the recent years, the banking sector witnessed numerous changes in the regulations.During this period, the banks faced numerous shocks.As a result, the efficiency of the banks has changed.The thesis aims to provide an analysis of the shocks and reforms in the banking sector on bank efficiency.The results contribute to the growing literature on the importance of the shocks and reforms in the banking sector.Chapter 5 presents the major conclusions of this thesis and summarises the main findings. This chapter also provides recommendations for future research that are beyond the scope of this research.

Chapter 2

EBA's Capital Exercise and Technical Efficiency of the banks.

2.1 Introduction

In October 2011,the European Banking Authority (EBA),the institution charged with setting harmonised supervisory standards for banks in EU member states, announced that major European banking groups would have to increase their core tier 1 capital ratios to 9 percent of their risk-weighted assets by June 2012 (EBA, 2011b). Additionally, these groups were required to hold a new temporary capital buffer to cover risks linked to sovereign bond holdings. The main objective of the capital exercise was to restore the confidence in the bank sector by ensuring the banks were adequately capitalized to mitigate the unexpected losses.The new requirement was considerably higher than the 5% requirement at the June 2011 stress test. The banks were provided with a very short time window to comply with the new requirements in the face of a deepening sovereign debt crisis. Moreover, the capital exercise announcement came soon after the stress tests conducted by the EBA in July 2011.This announcement came when the euro area was still considered to be extremely fragile, following a tumultuous summer on the sovereign debt markets of several member states. Many observers were concerned that impaired bank balance sheets were leading to weak credit supply and aggravating the recession in several countries.

The characteristics of the EBA's capital exercise are quite unique. Firstly,the announcing of the capital exercise was unexpected.The EBA announced this exercise just a few months after drawing tough conclusions from its own July 2011 stress test. In this stress test, none of the eight banking group failed. This surprise effect limits the odds that participating banks could have preemptively adjusted their balance sheets, which would bias downward the estimated effect on lending.Additionally, the new capital requirement was was substantially higher than that planned under the transition to Basel III.This exercise was not elated to the level of risks of any particular banking group,but rather to ensure that all large European banks accumulated sufficient capital cushions to withstand a further deterioration in the sovereign debt crisis(Mésonniera and Monksb, 2015).The time horizon set by the EBA to comply with this higher capital requirement is short when compared with the other requirements.For example, Basel III allowed the banks to have a transition period before the regulations are fully implemented.All these characteristics provides us with an opportunity to observe a exogenous regulatory shock to the bank capital.

The capital structure in the banking sector is considered to be more significant than the other industries because of informational failures, principal-agent issues, bankruptcy costs, taxes, and regulation. Capital acts as a buffer against loss, and hence failure with limited liability. The proclivity for commercial banks to engage in high-risk activities is curtailed when greater amounts of capital are at risk. By having a higher capital adequacy ratio in place, it would be giving the depositors more confidence in a bank's security and forms a type of internal fund resource. Additionally, it has been seen that the large banks tend to hold capital in excess of the most stringent regulatory requirements as a response to perceived risk exposures and in some instances, with the aim of maintaining their future profit streams. If the bank is required to have more capital, the upside gains they would be enjoying from the greater risk-taking would be countervailed by the potential downside loss of their capital. Therefore, it is significant to align the capital adequacy regulations with the incentives of banks with depositors and other creditors.This would contribute to more careful lending and better bank performance.In the existing literature, there appears to be mixed results regarding how the capital regulations would be affecting the efficiency of the banks.

Indeed, any attempt to evaluate the impact of a capital requirement shock on the lending supply faces several challenges. First, new regulations, such as Basel I to III, have generally been announced well ahead of their implementation explicitly to allow banks to smoothly adjust their balance sheets. This makes the task of identifying an unexpected shock to capital requirements and measuring the short-term impact on loan supply quite difficult. Second, as with the 2007-09 subprime crisis, regulators may increase requirements on account of a deterioration in the credit quality of borrowers during a downturn. Similarly to the difficulty of measuring the impact of a bank capital shock more generally, disentangling demand and supply effects is therefore not straightforward. Third, changes to bank regulations tend to affect all large banks of a given country at the same time, making it difficult to construct appropriate control groups of untreated but similar institutions.

The theoretical literature on the relationship between bank capital and credit supply suggests that banks may respond to a shock that increases their capital constraint by reducing credit supply (Mésonnier and Monks, 2014).Mésonnier and Monks (2014) investigated the impact of a regulatory shock tightening bank capital requirements on lending to the real economy.The results reveal that the exercise had pro-cyclical macroeconomic effects on credit supply.This means that the banks that were not constrained to recapitalise did not substitute for more constrained lenders. Gropp et al. (2018) showed that the banks did not raise their capital ratios by increasing their levels of capital, but by reducing their risk-weighted assets, in particular their credit exposures to corporate and retail clients.Furthermore,they suggest that the bank were reluctant to issue new equity to increase their capital ratios when required to do so by regulators.The evidence of these paper point out that the EBA's capital exercise had a damaging impact on bank lending in Europe with adverse affect on the economy.

This study is closely related to the literature examining the effect of the capital shock on the bank's technical efficiency.Barth et al. (2013a) investigated the efficiency of the banks in 72 countries for the period 1999 to 2007 using worldwide surveys on bank regulation.They suggest that greater capital restrictions are marginally and positively associated with bank efficiency.The findings suggest that the stricter capital regulations would contribute to re-

ducing the bank risk,but not be a highly significant benefit for the efficiency gains.VanHoose (2007) found that by having stricter capital regulations in place, the efficiency of the banks would be improving only if the regulatory screening ability is low.When the capital regulations are placed, the banks are looking for different asset portfolios which would generate better returns and requires the different resources to be managed.Therefore, the EBA's capital exercise raises questions about the bank's management of its resources efficiently.

This study attempts to fill in the gap by providing evidence on how the EBA's capital shock impacted on the efficiency of the banks. To do so, the study conducts an analysis of the impact of the capital shock on the efficiency scores estimated by Bootstrap Data Envelopment Analysis(DEA).The study uses the balance sheet data of the banks, macroeconomic conditions, financial development, and market structure to investigate the impact on bank efficiency while controlling for bank-specific factors. To my best knowledge, this is the first study to do so. The study uses a sample of 194 banks from 15 countries that are comprehensive in terms of geographical coverage. The EBA's capital exercise made the banks to reconsider their activities in the banking sector and to manage their portfolios better. It has aimed to make the banking market less concentrated. The results show that the mean of the Technical Efficiency for the banks in the sample equal .494 and .475 for before and after the capital exercise announcement was made by the EBA respectively. Following this, Simar and Wilson (2007) Double Bootstrap Truncated results provide evidence of the factors which determine the efficiency of the banks before and after the announcement has been made. With respect to the bank-specific characteristics, after the announcement, it is found that Non-Performing Loans, Return on Equity and Loan Activity of the bank are statistically significant and have a negative impact on the efficiency of the bank. While the capital of the bank has a statistically positive impact on efficiency. When taking macroeconomic conditions into account, it is found that after the announcement Capital of the bank is statistically significant and has a positive impact on the efficiency of the bank, and Return on Equity and Loan Activity have a negative impact. While the real GDP growth has a statistically positive impact on the efficiency of the bank.When controlling for the financial development, the size of the bank, the

size of the market, and the activity in the banking sector are significant and have a positive impact on the efficiency, and Return on Equity has a negative impact. When controlling for the market structure, the loan activity, return on equity and non-performing loans have a significant and negative relationship with the efficiency. Finally, controlling for all the factors, the loan activity, return on equity, and market concentration has a statistically significant and negative impact while financial development and real GDP growth have a statistically significant and positive impact on efficiency. Furthermore, the capital exercise contributed to stabilising the technical efficiency over the years.The EBA's capital exercise has contributed towards making the banks more stable and having less likelihood of having financial distress. Additionally, it would be preventing banks from excessive risk-taking activities.As the exercise would create an environment for careful lending and better bank performances.

The empirical results suggests that the capital requirements not only strengthen financial stability , but also make the technical efficiency of the banks more stable. The results will be helpful for the EBA and the other regulators to make the relevant policies. The results show the capital exercise would be preventing the banks from excessive risk-taking activities. Furthermore, it would be allowing the banks to withstand the financial distress. Although, the capital requirements would not be a highly significant benefit for the efficiency gains. But, it would be creating favourable economic conditions which would be affecting the extent, depth, and quality of financial intermediation and banking services.

The rest of the study is structured as follows. Section 2.2 provides an overview of the EBA's capital exercise and a review of studies that investigated the efficiency and capital requirements. Section 2.3 outlines Data Envelopment Analysis while Section 2.4 presents the sample and variables used in the study. Section 2.5 and 2.6 discusses the results and Section 2.7 concludes the study.

2.2 Literature Review

2.2.1 EBA's Capital Exercise

On October 26, 2011, The EBA announced its capital exercise which required banks to strengthen their capital positions by building up a temporary capital

buffer against sovereign debt exposures and to raise their core tier 1 capital ratio to 9% (EBA, 2011a). The banks were required to meet these requirements by June 2012.The new requirement was considerably higher than the 5% requirement in the June 2011 stress test.The exercise aimed to build confidence in the ability of euro-area banks to withstand credit shocks by ensuring the banks were adequately capitalized.

The elements of the EBA's capital exercise are fairly unique.Firstly, the announcement of the capital exercise was unexpected.The EBA announced this exercise just a few months after drawing tough conclusions from its own July 2011 stress test. In this stress test, none of the eight banking groups failed. This surprise effect limits the odds that participating banks could have preemptively adjusted their balance sheets, which would bias downward the estimated effect on lending.Secondly,The level of the new required core-tier-1-to-RWA ratio was substantially higher than that planned under the transition to Basel III (BIS, 2011b).his exercise was not elated to the level of risks of any particular banking group,but rather to ensure that all large European banks accumulated sufficient capital cushions to withstand a further deterioration in the sovereign debt crisis(Mésonniera and Monksb, 2015).Furthermore, the time horizon set by the EBA to comply with this higher capital requirement is short when compared with the other requirements.For example, Basel III allowed the banks to have a transition period before the regulations are fully implemented.All these characteristics provides us with an opportunity to observe a exogenous regulatory shock to the bank capital.

The EBA published an initial country-level estimate of required capital raising on October 26, 2011. On December 8, 2011, it published a formal recommendation with bank-level figures based on September 2011 balance sheet data (EBA, 2011c). Twenty-seven banks were identified as having an aggregate capital shortfall of €76 billion and were required as a consequence to submit capital plans to the EBA through their national supervisory authorities by January 20, 2012. (EBA, 2011c).The EBA published a preliminary assessment of the plan in February 2012 and emphasised that the measures were observed not be having any negative impact on the lending into the real economy (EBA, 2011c). In July 2012, the preliminary report was published and the majority of the banks had met the capital requirements. The final report, including

end-June 2012 detailed balance sheet information for all participating banks was published on October 3, 2012 (EBA, 2012).

Numerous researchers have criticised the timing of the capital exercise due to potentially aggravating the credit crunch in the Euro area (Mésonniera and Monksb, 2015). However, The EBA consistently emphasised the need to address the capital shortfalls without constraining credit provision in the real economy.For example, the recommendation of December 8, 2011, outlined a hierarchy of capital-raising measures, emphasising the use of liability management and stating that national authorities could only agree to asset disposals if they did not "lead to a reduced flow of lending to the EU's real economy" (EBA, 2011c). Furthermore, the EBA and national authorities were to ensure that capital targets were "not achieved through excessive deleveraging, disrupting lending into the real economy" (EBA, 2011c). In total, the twenty-seven banks increased their capital by €115.7 billion (EBA, 2012). According to the EBA's final report, €83.2 billion of this was related to direct capital measures, while €32.5 billion was related to the impact of RWA measures (EBA, 2012). Contributing to the latter figure was a fall in RWAs of €42.9 billion (0.87 percent of total RWAs as of September 2011) arising from reductions in lending (EBA, 2012). The EBA concluded: "In line with the Recommendation, capital plans have not led directly to a significant reduction of lending into the real economy. A deleveraging process had already started before the capital exercise and will need to continue in an orderly fashion" (EBA, 2012). The theoretical literature on the relationship between bank capital and credit supply suggests that banks may respond to a shock that increases their capital constraint by reducing credit supply (Mésonnier and Monks, 2014).Mésonnier and Monks (2014) investigated the impact of a regulatory shock tightening bank capital requirements on lending to the real economy.The results reveal that the exercise had pro-cyclical macroeconomic effects on credit supply.This means that the banks that were not constrained to recapitalize did not substitute for more constrained lenders. Gropp et al. (2018) showed that the banks did not raise their capital ratios by increasing their levels of capital, but by reducing their risk-weighted assets, in particular their credit exposures to corporate and retail clients.Furthermore,they suggest that the bank were reluctant to issue new equity to increase their capital ratios when required to do

so by regulators.The evidence of these paper point out that the EBA's capital exercise had a damaging impact on bank lending in Europe with adverse affect on the economy.Juelsrud (2018) found that the bank's estimated conditional capital shortfall increases when capital requirements increase. This effect is larger for initially risky banks. The primary reason for this decrease is that capital requirements reduces the market value of equity. He also suggests that the long-run marginal expected shortfall of treated institutions increases, indicating that capital requirements not only affects the valuation of banks but also the moments of their equity return distribution.

2.2.2 Efficiency

Over the years, bank efficiency has been on the top of the most research agenda. This is because there have been numerous changes in the regulatory and operating environment.These changes among the banks contribute to making the banks more concerned regarding the controlling of their costs while optimising revenues (Chortareas et al., 2013).They suggest that a more effective management in controlling costs while maximising the revenues in contexts characterised by the policies which improve bank's degree of freedom.Therefore, it results in a more efficient resources allocation process. Efficiency makes the banks more resilient to the external shocks (Diallo, 2018).This affects positively and significantly the growth rate of the banks which are more dependent on external financing.The efficiency of banks helps the economy by fostering economic growth and increasing prosperity. An effort to increase the efficiency levels is a new battle faced by the management.

Definition

In simple terms, efficiency is the ratio of the output to the resources used. Efficiency in the most simple expression is the maximise result in micro and macroeconomic level.Efficiency measures more directly reflect the bank's response to market discipline.This is because they are less likely to be reflected by factors other than bank behaviour.Efficiency is considered to be important for the banks because any improvement in the efficiency of the banking system would be contributing in improving savings,investment and resource allocation process and potential facilities over the country which would be used for the

development and general welfare(Hosseininassab et al., 2013).

From an economic theory point of view,efficiency is the result of optimised production and resource allocation. In other words, in a production unit managers and workforce,according to the desired goals of the firm and the available technological ability, are trying to determine their production amount, in a way that while using the maximum resources and possibilities, and optimal cost allocation, make optimal use of productive factors (Hosseininassab et al., 2013).Efficiency is a relative concept and to measure it and to understand the distance between efficiency and expected and ideal levels, we should be comparing the performance of the economic units with efficiency in potential production circumstances (Hosseininassab et al., 2013).

According to Andries and Ursu(2016), the term efficiency for banks means improved profitability, a greater amount of funds channelled in, better prices and services quality for consumers, and greater safety in terms of improved capital buffer in absorbing risk.Bank efficiency is measured by a bank's ability to convert its inputs into output while maximising profits or minimising costs (Belke et al., 2016).A bank would be considered to be inefficient if it uses numerous inputs which are greater than the number of outputs.Additionally, it would be considered inefficient if the inputs are allocated in the wrong proportions.These measurements of efficiency are least affected by endogeneity criticism than the financial volume measures because of the bank's ability to covert its inputs should influence growth independently of whether the economy is growing fast or slowly (Belke et al., 2016).An efficient bank should be considering to support the growth of the economy by choosing the optimal projects for funding and assigning the optimal costs with the risks at the same time (Belke et al., 2016).It is significant for the banks to improve their efficiency because efficiency has a direct impact on the performance and profitability of the banks (Xu et al., 2015).

Technical Efficiency

Numerous researchers have focused on the technical efficiency of the banks. Technical efficiency is related to the production of output(s) given some input(s).A production plan is technically efficient if there is no way to produce more output(s)with the same input(s) or to produce the same output(s) with

less input(s).Technical Efficiency is associated with the efficient use of the inputs within the bank's technology(Staub et al., 2010). This efficiency explains a larger part of the overall efficiency that could be inferred as under-utilisation or wastage of inputs. This measure of the efficiency indicates whether a bank uses the minimum quantity of inputs to produce a given quantity of outputs or maximises the output quantity given a certain quantity of inputs.Allocative efficiency refers to the ability of the bank to use the optimum mix of inputs given their respective prices.

Cost Efficiency

Cost efficiency is the product of technical efficiency and allocative efficiency. Cost efficiency shows the ability of the bank to provide services by optimum use of the resources at its disposal. Allocative efficiency or technical efficiency guides for the bank to become more cost efficient and helps in reducing the wastage of the resources. Cost efficiency helps in indicating how close a bank's cost is to that a best practice bank's cost would be producing the same outputs under the same conditions.Therefore, Cost efficiency is considered as a wider concept than technical efficiency.Cost efficiency refers to both technical efficiency and allocative efficiency.

Profit Efficiency

Profit efficiency indicates how close a bank is to earn the profit that a best-practice bank would be earning under the same condition.It measures how close to the minimum cost or maximum profit a bank is.Profit efficiency is a much wider concept because it includes both cost and revenues in the measurement of efficiency.The computation of profit efficiency is an important source of information for bank management than the partial vision offered by analysing cost efficiency.

2.2.3 Efficiency and Capital Requirements

In banking,the capital structure is considered to be more significant than the other industries because of informational failures, principal-agent issues, bankruptcy costs, taxes, and regulation.If the regulator decides to put capital regulations in place, then this would be influencing the following: - 1.The

quantity and quality of lending made by the banks 2.The decision of the banks when allocating their asset portfolios 3.The decision of the banks in relation to the sources of their funds. As a result of these factors, capital regulations would be affecting the efficiency of the banks. The capital regulations specify the amount of capital that a bank must have at risk. If the bank is required to be holding more capital at risk, then the gains made from the high risk-taking would be countervailed by the potential downside loss of their capital.

Risk Taking

Capital acts as a buffer against loss, and hence failure with limited liability (Wang, 2014). The proclivity for commercial banks to engage in high-risk activities is curtailed when greater amounts of capital are at risk. Generally, it is expected that the capital adequacy ratio exhibits a positive relationship with a bank's value(Wang, 2014).This allows the banks carry out careful surveillance of the risks arising from environmental uncertainty and economic volatility. Numerous researchers have found that a higher capital adequacy ratio would result in smaller tax deduction or lower risk by having a higher proportion of equity to debt, which contributes towards the higher risk-taking behaviour. By having a higher capital adequacy ratio in place,it would give the depositors more confidence in a bank's security and forms a type of internal fund resource.Additionally, it is witnessed that the large banks tend to hold capital in excess of the most stringent regulatory requirements as a response to perceived risk exposures and in some instances, with an aim of maintaining their future profit streams(Chortareas et al., 2011). If the banks are required to have more capital, the upside gains they would enjoy from the greater risk-taking would be countervailed by the potential downside loss of their capital. Therefore, it is significant to align the capital adequacy regulations with the incentives of banks with its depositors and other creditors. This would be contributing to more careful lending and better bank performance. However, this belief is based on the public interest view and tends to ignore possible regulatory costs which would be in the form of a high barrier to entry and greater rent extraction by the governments that result from higher capital requirements.

Barth et al. (2013b) found that the capital adequacy regulations have a significant role in relation to the incentives of the bank with depositors and other

creditors. This would be contributing to more careful lending practices and better bank performance. The capital regulations influence the decision of the banks regarding the mix of deposits and equity.The deposits and equity bears different costs for the bank.It is costly to raise the equity for the banks.By raising the equity, the bank will face permanently higher funding costs, which in turn will permanently reduce the supply of lending.Furthermore, they found that greater capital regulation stringency is marginally and positively associated with bank efficiency.They suggest this is due to the dominant effect on bank efficiency may be actual capital rather than the stringency of the capital regulations. VanHoose (2007) investigated the effects of capital regulations on the banks. He found that by having stricter capital regulations in place, the efficiency of the banks would be improving only if the regulatory screening ability is low. Additionally, if the regulatory screening ability is high, the efficiency would improve if there are loose capital regulations. When the capital regulations are placed, the banks are looking to substitute the loans with alternative forms of assets. The banks look for different asset portfolios which would generate better returns and require the different resources to be managed. Therefore, the capital regulations raise questions about the bank's management of its portfolio of different assets efficiently.

Moral hazard is defined as excessive risk-taking when another party is bearing part of the risk and could not be changed easily for or prevented from that risk-taking. Most of the empirical research has found that high capital ratios would prevent the moral hazard from taking place between shareholders and managers. This contributes to improving the efficiency of the banks. This research has investigated the conflicts between shareholders and managers. Usually, they support the notion that both efficiency and capital are relevant determinants of a bank's risk-taking and more hazard incentives.Berger and DeYoung (1997)found that the banks with less capital would respond to the moral hazard incentives by taking higher portfolio risks. As a result, there is a decrease in the capital ratio of the banks before an increase in non-performing loans for banks with low capital ratios. This would cause a decline in the efficiency levels of the banks.

Financial Stability

Barth et al. (2013b) investigated the efficiency of the banks in 72 countries for the period 1999 to 2007 using worldwide surveys on bank regulation.Using DEA, they found that tighter regulations on banking activities have a negative impact on bank efficiency. While greater capital restrictions are marginally and positively associated with bank efficiency. These findings imply that there are potential trade-offs between bank soundness and efficiency. This means that stricter capital regulations have a weak relationship with bank efficiency. The stricter capital regulations would contribute to reducing the bank risk, but not be a highly significant benefit for the efficiency gains. Pasiouras et al. (2009)investigated the impact of the banking regulations on bank's cost and profit efficiency for banks operating in 74 countries during the period 2000-2004. They found that the stricter capital requirements would improve the cost efficiency and reduce profit efficiency. This would explain by having stricter capital requirements, the likelihood of financial distress reduces.The lower profit efficiency is explained by the bank's balance sheet getting more inclined towards liquid and lower return assets.

Chiu et al. (2008) investigated the efficiency of Taiwan banks for three years from 2000 to 2002 using DEA. They found that the average efficiency scores of banks with high capital adequacy are significantly higher than those of banks with lower capital adequacy. They suggest that the banks with a better financial status and lower relative risk operate with more efficiency.Furthermore,they conclude that banks with high capital adequacy have no intention to engage in business with high risks. Therefore, the probabilities of defaults and losses are relatively low, which lead to the high efficiency of the banks in the long run.

Asset Quality

Bitar et al. (2016) investigated the impact of capital ratios on risk, efficiency, and profitability in the Middle East and North Africa region using risk-based regulatory ratios and non-risk-based traditional capital ratios for the period 1999 to 2013. They found that banks with higher capital ratios have higher loan loss reserves and are more efficient. They found that higher proportions of net loans in bank total assets improve bank efficiency. This is because

banks with higher capital ratios have higher loan loss reserves to be commensurate with the amount of risk taken.Additionally,capital provides the bank with an ability to absorb losses as well as its role in reflecting bank asset quality. Barth et al. (2013a) investigated the relationship between capital regulations and non-performing loans. There are less non-performing loans when rigorous capital regulations are in place.This is because rigorous capital regulations makes the bank become more active in the credit management of their portfolio. Bitar et al. (2018)analysed the impact of the capital on risk, efficiency, and profitability of banks in 39 OECD countries during the period 1999-2013.They found that risk-based and non-risk-based capital ratios increase bank efficiency. Their findings show that requiring highly liquid banks to hold higher capital may hinder their efficiency. The asset growth is positively associated with bank efficiency. Their results show the bank size to have a positive relationship with bank efficiency. This suggests that larger banks benefit from economies of scale. Additionally, they found that GDP growth is positively correlated with bank efficiency. The banks in countries with higher GDP growth are more efficient and more profitable. These banks tend to hold smaller loan loss reserves that reflect favourable economic conditions. These studies show the significance of bank-specific, industry-specific, and macroeconomic variables on bank efficiency.

Macroeconomic Conditions

By controlling for bank-specific, industry-specific and macroeconomic variables, which are supposed to influence the efficiency, capital and risk relationship, Tan and Floros (2013) examined the relationship between efficiency, risk, and capital in the Chinese banking industry. They found that bigger banks (in terms of total assets) have higher technical efficiency. Furthermore, in a higher concentrated banking market, the technical efficiencies of Chinese banks are lower. Also, they found GDP growth rates have a positive impact on efficiency. Wheelock and Wilson (1995) using the micro-level historical data to examine the causes of bank failure. The results indicate that increasing inefficiency increases the probability of bank failure. The probability of failure would be higher for a bank that was less efficient at transforming labour, capital, and financial inputs into earning assets and demand deposits.The lower a bank's

capital/assets or cash/deposits ratios, the more likely it was to fail.Färe et al. (2004)investigated the effect of the regulatory constraint such as risk-based capital constraint and leverage constraint on the efficiency. Using a sample of banks from 1990,1992, and 1994 Call Reports, they found that relaxing the regulatory constraints leads to greater technical inefficiency. The results showed the significance of the regulatory constraints on the technical inefficiency.

2.2.4 Data Envelopment Analysis and Efficiency

The non-parametric method in productivity evaluation was found by Farrell in 1957. This method was developed in 1978 by Charnes, Cooper, and Rhodes based on mathematical programming models. It was entitled Data Envelopment Analysis (DEA). This technique was introduced as an efficient method for evaluating decision-making units function. Following the development of DEA, in 1984, the returns to scale concept in DEA models were considered by Banker, Charnz, and Cooper. DEA has been widely used for measuring the efficiency in the banks. DEA is a linear program in the form of a piecewise linear combination that presents a set of best practice observations and evaluates the performance by relating the input and outputs relating to the common efficiency frontier(Xu et al., 2015).

DEA measures the relative efficiency in situations in which there are multiple inputs and outputs and there is no obvious objective way to aggregate either inputs or outputs into a meaningful index of productive efficiency (Holod and Lewis, 2011). In its basic form, DEA considers a collection of decision-making units (DMU) each of which consumes DMU-specific levels of selected inputs to produce DMU-specific levels of selected outputs (Holod and Lewis, 2011).DEA makes no assumptions regarding how a DMU converts inputs into outputs. DEA establishes an efficiency frontier based on observed best performances and evaluates the efficiency of each DMU relative to this frontier. DMU that lie on the frontier is considered as efficient. When DEA is applied in evaluating the performances of a set of banks, it is possible to form two groups such as one that comprises an efficient frontier and the other with the banks lying below the frontier(Titko et al., 2014). When DEA is applied, the efficiency score is estimated as the ratio of weighted outputs to weighted inputs (Titko et al., 2014). The weights are selected for each variable of every anal-

ysed unit to maximise its efficiency score.DEA has been widely used because of the advantages it has over traditional parametric methods. DEA makes each DMU look as favourable as possible to its peers by allowing each DMU to choose its own variable inputs. This feature makes DEA a better option when assigning numerical values to the variables that are qualitative in nature. Additionally, DEA has the ability to identify a reference unit for each DMU. This proves to be a very useful managerial tool because it helps in determining the potential causes and remedies for the identified inefficiencies(LaPlante and Paradi, 2015). Furthermore, DEA does not require to make any prior assumptions of the observation's distribution. Using DEA allows comparing the banks of different sizes in different countries with respect to one EU-wide frontier without imposing any specific parametric functional form (Casu and Girardone, 2010).In literature, the estimations of profit efficiency using DEA is limited. This is because of the difficulty in collecting reliable and transparent information for the output prices (Fethi and Pasiouras, 2010). Moreover, it is not straightforward to decompose profit efficiency into technical efficiency and allocative efficiency. Färe et al. (2004)proposed the solution of two sets of linear programming. In the first case, a profit maximising DEA is solved for measuring the profit efficiency. In the second case, technical efficiency is measured based on a directional distance function, which allows the simultaneous adjustment of inputs and outputs. Additionally, the DEA model is often used in measuring bank efficiency is because the managers have higher control over the inputs rather than over outputs (Titko et al., 2014).

In DEA related research papers, the determination of the model variables i.e., the combination of inputs and outputs is the most discussed topic. Primarily, the selection is based on three basic approaches to banking: - the intermediation approach, the production approach, and the profitability approach. The intermediation approach emphases the intermediary role played by the bank. Loans and Securities are treated as outputs, whereas deposits, labour, and capital as inputs. The production approach assumes that banks use capital and labour to produce different kinds of banking products such as loans and deposits. The profitability approach is similar to the production approach. However, the outputs of the profitability approach are more profit-oriented such as interest income and non-interest income. The choice of a

model specification has a significant impact on the results of the research. It is well known that DEA is sensitive to the variable selection. When selecting the model's variables, statistically rigorous methods should be applied. The choice of the number of variables selected is significant because the greater numbers of variables a DEA model has, the more efficient DMUs will be. Therefore, it contributes to an increase in the number of efficient banks. Additionally, the application of the DEA should be done with caution and the factors such as country-specific and industry-specific should be taken into consideration.

For ensuring the validity of the DEA model specification, an isotonicity test should be conducted. An insotonicity test involves the calculation of all the inter-correlations between inputs and outputs for identifying whether increasing the amounts of inputs leads to greater outputs (Tsolas and Charles,2015). If the inter-correlation between inputs and outputs is observed positive, the insotonicity test is passed. Therefore, the inclusion of inputs and outputs is justified. The deepening of the recent crisis and continued banking fragility led to banks requiring state support arrangements. This contributed to creating the need for a reassessment of the banking systems' performances. The research on the performances of the financial institutions focuses especially on frontier efficiency (Andries and Ursu,2016). This involves measuring the performance deviations of some institutions from the efficiency frontiers which is already built based on the best practices. This technique allows us to measure how efficient the institution is in comparison to the most efficient institution in the market. The results obtained from the frontier efficiency could be used for the formulation and guidance of the regulation. This would be done by assessing the effects of deregulation, mergers, or market structure on the efficiency by identifying the best and worst practices associated with high and low measured efficiency. For the banks, efficiency means improved profits, greater amounts of funds channelling in, better prices and services quality for the consumers, and greater safety in relation to improved capital buffers for absorbing the risk. Additionally, the frontier techniques could be used for measuring the impact of the major economic events such as crisis, on the performance of the banks.

Pasiouras et al. (2006) used the country-level data and bank-level data from 71 countries and 857 banks to investigate the impact of bank regula-

tions, supervision, market structure, and bank characteristics on individual bank ratings. Pasiouras (2008a) using DEA investigated the Greek commercial banks for the Greek commercial banks over the period 2000-2004. He found that there is a positive relationship between capital requirements and technical efficiency. However, this is not statistically significant in the different combinations of inputs and outputs used in the DEA model. Defung et al. (2016) investigated the technical efficiency of the banks in Indonesia for the period 1993-2011 by employing DEA. They found that the strengthening of the banking system with higher capital to asset ratios, higher minimum reserve requirements, and enhanced supervision led to lower efficiency in the intermediation approach. However, these reforms have led to an increase in revenue efficiency.Santos (1999) used an intermediation model to study the efficiency and welfare implications of the banks' minimum required capital–asset ratio. The results reveal that a bank's stability and efficiency would improve if there are capital regulations in place.

2.3 Data Envelopment Analysis

Data Envelopment Analysis (DEA) has been widely used in measuring the efficiency in banks. DEA is a linear program in the form of piecewise linear combination which presents a set of best practice observation and evaluates the performance by relating the input and outputs relating to the common efficiency frontier (Xu et al., 2015). DEA measures the relative efficiency in situations in which there are multiple inputs and outputs and there is no obvious objective way to aggregate either inputs or outputs into a meaningful index of productive efficiency(Holod and Lewis, 2011). In its basic form, it considers a collection of decision-making units (DMU) each of which consumes DMU-specific levels of selected inputs to produce DMU-specific levels of selected outputs(Holod and Lewis, 2011). DEA makes no assumptions regarding how a DMU converts inputs into outputs. DEA establishes an efficiency frontier based on observed best performances and evaluates the efficiency of each DMU relative to this frontier. DMU that lie on the frontier is considered as efficient. When applying DEA in evaluating the performances of a set of banks, it is possible to form two groups such as one that comprises an efficient frontier and

the other with the banks lying below the frontier (Titko et al., 2014). When DEA is applied, the efficiency score is estimated as the ratio of weighted outputs to weighted inputs (Titko et al., 2014). The weights are selected for each variable of every analysed unit to maximise its efficiency score. The efficiency rate for each unit of the reference set of j = 1,. . . .,n banks, is evaluated in relation to the other set members. Each DMU is assigned an efficiency score which ranges between 0 and 1. The score equal to 1 indicates an efficient DMU with respect to the rest of the DMUs in the sample. The maximum efficiency score is 1 and the lower values indicate the relative inefficiency of the analysed objects.

$$Efficiency = \frac{Weighted\ sum\ of\ Outputs}{Weighted\ sum\ of\ inputs} \tag{2.1}$$

Accordingly, the mathematical equation to find the maximum efficiency of DMUs using weighted input-output efficiency measure could be expressed as:-

$$Max\ h_0 = \frac{\Sigma_{r=1}^{s}(u_r y_{r0})}{\Sigma_{i=1}^{m}(v_i x_{i0})} \tag{2.2}$$

such that

$$0 \leq \frac{\Sigma_{r=1}^{s}(u_r y_r)}{\Sigma_{i=1}^{m}(v_i x_i)} \leq 1; j = 1, 2, ...n. \tag{2.3}$$

$$u_r, v_r \geq 0; r = 1, 2, \ldots .s; i = 1, 2, \ldots .m. \tag{2.4}$$

In this formulation, "o" denotes a focal DMU (i.e., each bank, in turn, becomes a focal bank when its efficiency score is being computed). x_{ij} is the observed amount of the i^{th} input of the j^{th} DMU, y_{rj} is the observed amount of the r^{th} output of the j^{th} DMU. u_r and v_i are non-negative weights which are determined by the above linear programming. However, one may find out an infinite number of solutions by solving such programming approach, if (u^*, v^*) is a solution, then $(\alpha u^*, \alpha v^*)$ is another solution for any non-negative α. Charnes et al.(1978) imposed the constraint $\Sigma_{i=1}^{m}(v_i x_{i0}) = 1$, which provides :

$$Max\ z_0 = \Sigma_{r=1}^{s}(u_r y_{r0}) \tag{2.5}$$

$$s.t. \Sigma_{r=1}^{s}(u_r y_r) - \Sigma_{i=1}^{m}(v_i x_i) \leq 0; j = 1, 2, \ldots, n. \tag{2.6}$$

$$\Sigma_{i=1}^{m}(v_i x_i) = 1 \tag{2.7}$$

$$u_r, v_i \geq 0; r = 1, 2, \ldots . s; i = 1, 2, \ldots . m. \tag{2.8}$$

In order to derive an equivalent envelopment form, the duality in linear programming is used:

$$Min\ z_0 = \theta_0 \tag{2.9}$$

$$s.t.\ \Sigma_{j=1}^{n} \lambda_j x_{ij} \leq \theta_o x_{io}; i = 1, 2, \ldots, m. \tag{2.10}$$

$$\Sigma_{j=1}^{s} \lambda_j y_{rj} \geq \theta_o y_{ro}; r = 1, 2, \ldots, s. \tag{2.11}$$

$$\theta_j \geq 0 \tag{2.12}$$

The objective function tries to minimise the efficiency θ_0 subject to the constraints such that the weighted sum of the inputs of the other DMUs is less than or equal to the inputs of the DMU being evaluated and the weighted sum of the outputs of the other DMUs is larger than or equal to the DMU being evaluated. The weights λ are non-negative values. The λ_j is an $jx1$ vector of the bank-specific weight that conveys information on the benchmark comparators for $bank_0$.Optimal solutions (θ, λ) are obtained by solving above linear programming N times, once for each DMU. The value of θ is called technical efficiency. The value of θ is always less than or equal to 1 based on the constraints and the efficiency score θ computed for each DMU is relative to other DMUs. Accordingly, DMU for which $\theta = 1$ is considered as technically efficient firm and their input-output mix lies on the efficient institutions and their input-output mix lies on the efficient frontier. The optimal λ identify benchmarking points (best performers) which are located on the efficient frontier when the problem seeks the reduction of inputs. The target DMU is technically efficiency if and only if the value of θ at the optimality is equal to 1 and so it is not possible to make improvement without worsening any other input or output. If $\theta = 1$ the bank is efficient as it lies on the frontier, whereas if $\theta < 1$ the bank is inefficient and needs a $1 - \theta$ reduction in the inputs levels to reach the frontier. The linear programming is solved j times, once for each DMU in sample, and a value of θ is obtained for each DMU representing its efficiency score. Moreover, λ can identify the shape of the DEA frontier. Different constraints on λ could lead to different DEA models. The assumption of this model is a constant return to scale, which means that all DMUs are operating at an optimal scale. Therefore, this model is called the CRS model.

The first version of DEA assumes constant returns to scales (CRS) which means that a change in the inputs is followed by a change in the same proportion of the outputs (Charnes et al., 1978). CRS means that a condition when there is a proportionate increase or decrease of input or output causing the DMU to be moved along the frontier line or above it, and provide a meaningful measurement of technical efficiency. The output of this model is a score indicating the overall technical efficiency (OTE) of each DMU under CRS.

For measuring the bank efficiency, the input-oriented DEA models are most frequently used. The possible reason is that the bank managers have higher control over inputs rather than over outputs (Fethi, Pasiouras 2010). The input-oriented DEA model objects to maximise the proportional reduction in inputs as much as possible to achieve relative efficiency, given the same output level. The input-oriented model's target is to minimise the inputs while adequately satisfying the given output level. The input-oriented DEA model allows reducing inputs without changing outputs to achieve efficiency. These inputs reduction or savings are defined as input slacks. The input slacks can be seen as an important indicator to help bank managers to improve their banks' performances.

In the following years,Banker et al. (1984)employed a DEA model with variable returns to scale (VRS). This means VRS relaxes the constant returns to scale assumption and allows for the possibility that the bank's production technology might exhibit increasing, constant, or decreasing returns to scale. This model decomposes OTE into a product of two-component. The first is the technical efficiency under VRS or pure technical efficiency (PTE). This relates to the ability of the managers to utilise the firm's given resources. The second is scale efficiency (SE). This relates to exploiting the scale of economies by operating at a point where the production frontier exhibits CRS. The CRS linear programming is modified to consider VRS by adding the convexity by $N1'\lambda = 1$, where $N1$ is a $N1$ vector of ones. The technical efficiency scores obtained under VRS are higher than or equal to those obtained under CRS and SE could be obtained by dividing OTE with PTE. The VRS efficiency scores are higher or equal to the CRS efficiency scores because of the scale size of each DMUs.

In more technical terms, let us assume that there is data on K inputs and

M outputs on each of N DMUs. For the i^{th} DMU, these are represented by the vectors x_i and y_i respectively. The K x N input matrix , X , and the M x N output matrix , Y , represent the data for all N DMUs. The input oriented measure of a particular DMU , under CRS , is calculated as

$$Min_{\theta,\lambda}\theta \tag{2.13}$$

$$s.t. - y_i + Y\lambda \geq 0 \tag{2.14}$$

$$\theta x_i - X\lambda \geq 0 \tag{2.15}$$

$$\lambda \geq 0 \tag{2.16}$$

where $\theta \geq 1$ is the scalar efficient score and λ is $Nx1$ vector of constants. If $\theta = 1$ the bank is efficient as it lies on the frontier, whereas if $\theta < 1$ the bank is inefficient and needs a 1 - θ reduction in the inputs levels to reach the frontier. The linear programming is solved N times, once for each DMU in the sample, and a value of θ is obtained for each DMU representing its efficiency score.

DEA has been used for measuring the efficiency at the level of the bank branch, at the country level, and multi-country level. Schaffnit et al. (1997) investigated the efficiency of Ontario based branches of a large Canadian bank. The results indicated that the most efficient branches tend to be more profitable and deliver better quality service. They found a strong effect of the branch's neighbourhood density on its performance. The efficiency at the level of the bank branch is useful for the bank management to improve their service quality and utilize the available resources more efficiently (Paradi and Zhu, 2013). The efficiency at the country level is important for the development of financial regulation and financial regulators (Staub et al., 2010). Jemric and Vujcic (2002) investigated the efficiency of Croatia banks. They found that the decision of the regulators to privatize and for the entry of foreign banks was the correct decision. This contributed to an increase in efficiency and improving the operation of the market participants. Pasiouras (2008b) investigated the impact of regulations and supervision on the bank's technical efficiency using a sample of 715 banks from 95 countries. This analysis provides a comprehensive analysis of the relationship between bank efficiency and regulation and supervision approaches around the world. The cross-country analysis provides international evidence. Therefore, this study adopts a cross-country approach

to provide international evidence for the role of the EBA's capital exercise on technical efficiency.

DEA has different limitations. The most significant drawback is that DEA has no statistical properties.As a result, it tends to generate biased estimates.This major constraint limits the DEA's usefulness to decision makers (Ferrier and Hirschberg, 1997).This is because estimates of inefficiency offers no discussion of uncertainty surrounding the estimates due to sampling variations (Simar and Wilson, 2000).To correct the problems associated with the sampling noise in the resulting efficiency DEA estimators, and within the first stage initiated with the DEA, we use the procedure proposed by Simar and Wilson (2000) for bootstrapping the initial efficiency scores and obtaining bias-corrected efficiency estimations $\hat{\theta}$.The DEA bootstrap technique proposed by Simar and Wilson (2000) which provides statistical properties to DEA estimators and allows to obtain bias corrected efficiency scores.

Assuming n bank bank-year observations $(x_i, y_i), i = 1, \ldots, n$ that use multiple inputs x to produce multiple outputs y, a summary of the Simar and Wilson (2000) procedure to estimate pure technical efficiency of the sample observations is as follows:

1. For each bank-year observation $(x_k, y_k)k = 1, \ldots, n$ compute $\hat{\theta}_k$ using the following linear program formula:

$$\begin{aligned}\hat{\theta}_k = min\ \{\theta > 0 | y_k \leq \sum_{i=1}^{n} \lambda_i y_i; \theta x_k \ \geq \sum_{i=1}^{n} \lambda_i x_i; \\ \sum_{i=1}^{n} \lambda_i = 1; \lambda_i \geq\ 0\ \forall i = 1, 2, ...n\}\end{aligned} \tag{2.17}$$

   where λ is a vector of constant.

2. Draw with replacement from $\hat{\theta}_1, ..., \hat{\theta}_n$ to generate $\beta_1^*, ..., \beta_n^*$,

3. Smooth the sampled estimates using the following formula:

$$\tilde{\theta}_i^* = \begin{cases} \beta_i^* + h\varepsilon_i^*\ if\ \beta_i^* + h\varepsilon_i^* \leq 1 \\ 2 - \beta_i^* - h\varepsilon_i^*\ otherwise \end{cases} \tag{2.18}$$

   where h is the bandwidth of a standard normal kernel density and ε_i^* is a random error drawn randomly from the standard normal distribution.The cross-validation method can be used to determine the bandwidth parameter Simar and Wilson (2000).

4. Correct the variance of the bootstrap estimates by computing:

$$\theta_i^* = \overline{\beta}^* + \frac{\tilde{\theta}_i^* - \beta^*}{\sqrt{1 + h^2/\hat{\sigma}_{\hat{\theta}}^2}} \tag{2.19}$$

where $\overline{\beta^*}$ is the average of $\beta_1^*, ..., \beta_n^*$ and $\hat{\sigma}_{\hat{\theta}}^2$ is the sample variance of $\hat{\theta}_1, ..., \hat{\theta}_n$.

5. Generate pseudo-data set $\eta_b^* = (x_{ib}^*, y_i^*), i = 1, ...n$ given by $x_{ib}^* = \frac{\hat{\theta}_i}{\theta_{ib}^*} \times x_i$.

6. Calculate the bootstrap estimate of $\hat{\theta_{k,b}^*}$ for k = 1,. . . ,n by solving:

$$\begin{aligned} \hat{\theta}_{kb}^* = min\ \{\theta > 0 | y_k \leq \sum_{i=1}^{n} \lambda_i y_i; \theta x_k \ \geq \sum_{i=1}^{n} \lambda_i x_{i,b}^*; \\ \sum_{i=1}^{n} \lambda_i = 1; \lambda_i \geq\ 0\ \forall i = 1, 2, ...n\} \end{aligned} \tag{2.20}$$

7. Repeat the steps 2-6 with b = 2000 times to provide for k = 1,. . . ,n a set of estimates $\{\hat{\theta}_{k,b}^*, b = 1, ...B\}$.

For measuring the bank efficiency, the input-oriented DEA models are most frequently used. The possible reason is that the bank managers have higher control over inputs rather than over outputs (Fethi and Pasiouras, 2010). The input-oriented DEA model objects to maximise the proportional reduction in inputs as much as possible to achieve relative efficiency, given the same output level. The input-oriented model's target is to minimise the inputs while adequately satisfying the given output level. The input-oriented DEA model allows reducing inputs without changing outputs to achieve efficiency. These inputs reduction or savings are defined as input slacks. The input slacks can be seen as an important indicator to help bank managers to improve their banks' performances.

The present study would be reporting the efficiency estimates obtained under CRS. The efficiency scores obtained under CRS have been used by many earlier studies (Pasiouras, 2008a; Drake and Hall, 2003). The CRS assumption allows comparing large banks with smaller ones. The present study would be reporting the efficiency estimates obtained under CRS with input-orientation.

2.4 Variables

2.4.1 Inputs and Outputs

There is an on-going debate in the banking literature relative to the proper definition of input and output.Berger and Humphrey (1997) identified two main approaches for the selection of inputs and outputs. These are the 'production approach 'and the 'intermediation approach'. The production approach assumes that the banks produce loans and deposits account services by using labour and capital as inputs and that the number and type of transactions measure the outputs. The intermediation approach perceives the banks as financial intermediaries between savers and investors.Berger and DeYoung (1997)argues that neither of these two approaches is perfect because they cannot fully capture the dual role of financial institutions as providers of transactions and also being financial intermediaries. Moreover, they point out that the production approach is better for evaluating the efficiencies of bank branches and the intermediation approach is more appropriate for evaluating financial institutions as a whole. For the production approach, there are difficulties in collecting detailed transaction flow information. Therefore, the intermediation approach is more preferred in the literature. Recently, Drake, Hall et al. (2006) proposed a 'profit-oriented approach'. This approach defines revenue components as outputs and cost components as inputs. They point out that their results are suited to capture the diversity of strategic responses by financial firms in the face of dynamic changes in competitive and environmental conditions.

Generally, inputs are those which are desirable to be minimal and outputs are those which are desired to be maximised. In DEA, both input orientation and output orientation could be used for solving the problem. In the input-oriented model, the inputs are minimised whereas, in the output-oriented model, the outputs are maximised.

The review of the cross-country studies indicates that the intermediation approach is the most commonly used. This is consistent with the modern empirical literature of studies that examine individual countries. Following these studies, the intermediation approach is adopted. The model is estimated using 3 inputs and 3 outputs. The inputs are total deposits, total costs which consist of interest expenses and non-interest expenses and equity. Equity is

used to control for the differences in risk preferences. The outputs are loans, other earning assets, and non-interest income. For maximising profits, the minimisation of the total cost is needed (Casu and Molyneux, 2003). Consequently, the total cost is used. Equity is used to control for the differences in risk preferences (Pasiouras, 2008a) (Drake and Hall, 2003). The outputs are loans, other earning assets, and non-interest income. In the study, Total Loans produced by the bank is used as an output because this activity is highly resource-consuming, with substantial value-added (Berg et al., 1993). Numerous studies have used non-interest income as a proxy for off-balance sheet activities (Pasiouras, 2008). Table 2.1 presents descriptive statistics for the inputs and outputs.

Table 2.1: Description of Inputs and Outputs variables used for DEA.These variables are used in DEA for calculating efficiency scores.

Inputs	**Outputs**
1.Total Deposits	1.Loans
2.Total Costs	2.Other Earning Assets
2.1. Interest Expenses	
2.2. Non-Interest Expenses	
3.Equity	3.Non-Interest Income

2.4.2 Control Variables

In this study, five bank-specific and one country-specific control variables have been used. The country-specific variable account for the macroeconomic conditions.

The bank-specific variables are: LOGTA is the logarithm of bank's assets and controls for bank's size; NPL is loan loss provisions over total loans and is a measure of Asset Quality; ROE is the pre-tax profit divided by equity; EQASS is equity to assets ratios and is the measure for the capital strength of the bank and LOANTA is total loans over total assets and is a measure of loan activity. These variable have been used in the past studies to reveal the bank-specific characteristics which have an impact on the efficiency (Pasiouras et al., 2006; Pasiouras, 2008b).

Earlier studies have used different variables for controlling the macroe-

conomic conditions. In this study, the annual growth in GDP is used for controlling the macroeconomic condition. Earlier studies have found that the favourable conditions would be affecting positively the demand for the supply of banking services and would possibly contribute towards an improvement in the bank's efficiency.Maudos et al. (2002) found that the banks operating in expanding markets proxy by the real growth rate of GDP present higher levels of profit efficiency. However, under expansive demand conditions, banks would feel less pressurised to control their costs and could be less cost-efficient.

Numerous studies have found that overall financial development, measured by banking market size and levels of monetarization contributes to higher efficiency. In this study, these two variables are used for controlling for the development of the financial sector. These measures have been used in the studies of Demirgüç-Kunt and Huizinga (1999),Pasiouras (2008b) and Barth et al. (2008). The banking market size is calculated by dividing Assets of deposit money banks with GDP. Kasman and Yildirim (2006) found that market size has a positive relation with the bank efficiency.With a bigger market, a bank has more opportunities to generate better returns.Also, presents an opportunity to diversify its operations.The monetarization is calculated by dividing Bank claims to the private sector with GDP.

These variables reflect the bank development(Barth et al., 2013b).A lower bank development reduces the efficiency of financial intermediation (Barth et al., 2008).As the requirements are introduced, it restricts the bank's activities.As a result,it lowers the banking sector efficiency.

The study also controls for differences in the market structure among countries. This is done by using the degree of concentration. Earlier studies have found that less concentrated markets have higher efficiency. This measure has been used in the studies of Beck et al. (2006) and Pasiouras (2008b). This is measured as the percentage of assets held by the three largest commercial banks in the country. A highly concentrated commercial banking sector might result in lack of competitive pressure to attract savings and channel them efficiently to investors.A highly fragmented market might be evidence for undercapitalized banks. Furthermore, the degree of concentration acts as a measurement for the systemic risk (Nicoló et al., 2004).

2.4.3 Double Bootstrap truncated regression

Numerous studies have used Tobit regression in the second stage of the analysis.However, Simar and Wilson (2007) has criticised the use of Tobit regression.In their studies with Monte Carlo experiments, Simar and Wilson (2007) demonstrated that the explanatory variables are correlated with the error term as input and output variables are correlated with explanatory variables. Moreover, they pointed out that DEA efficiency estimates are serially correlated. As a result,they consequently yield inconsistent and biased estimates in the second-stage. To address this issue, Simar and Wilson (2002) proposed an alternative double bootstrapped procedure that permits the valid inference while simultaneously generating standard errors and confidence intervals for the efficiency estimates.Therefore,the study adopts Simar and Wilson (2007)'s double bootstrap method where the bias-corrected efficiency scores $\hat{\theta}_i^*$ yielded in the first-stage are regressed on a set of explanatory variables(z_i) using the following specification:

$$\hat{\theta}_i^* = \alpha + z_i\beta + \varepsilon_i, \qquad i = 1, .., n \tag{2.21}$$

where α is a constant term, β is a vector of parameters and ε_i is the statistical noise.

The bootstrap procedure proposed by Simar and Wilson (2007) is described in the following steps :-

1. Calculate the DEA input-orientated efficiency score for each bank, using the linear programming problem in (2.17). :

$$\begin{aligned}\hat{\theta}_k = min\ \{\theta > 0 | y_k \leq\ & \sum_{i=1}^{n} \lambda_i y_i; \theta x_k\ \geq \sum_{i=1}^{n} \lambda_i x_i; \\ & \sum_{i=1}^{n} \lambda_i = 1; \lambda_i \geq\ 0\ \forall i = 1, 2, ...n\}\end{aligned} \tag{2.22}$$

2. Use the Maximum likelihood method to estimate the truncated regression of $\hat{\theta}$ on z_i, to provide and estimate $\hat{\beta}$ of β and an estimate $\hat{\sigma}$ of σ_ε.

3. For each bank i = 1, ... , n, repeat the next four steps (a–d) B times to yield a set of bootstrap estimates $\{\hat{\theta}_{i,b}^*, b = 1, ...B\}$

   (a) Draw ε_i from the $N(0, \hat{\sigma}_\varepsilon^2)$ distribution with left truncation at $(1 - \hat{\beta}z_i)$.

(b) Compute $\theta_i^* = \hat{\beta} z_i + \varepsilon_i$.

(c) Construct a pseudo data set (x_i^*, y_i^*) , where $x_i^* = x_i$ and $y_i^* = y_i \hat{\theta}_i / \theta_i^*$.

(d) Compute a new DEA estimate θ_i^* on the set of pseudo data (x_i^*, y_i^*),i.e.γ and X are replace by $Y^* = \{y_i^*, i = 1, ...n.\}$ and $X^* = \{x_i^*, i = 1, ...n.\}$.

4. For each bank, compute the bias corrected estimate $\hat{\hat{\theta}}_i = \hat{\theta}_i - \hat{bias}_i$,where $\hat{bias}_i$is the bootstrap estimator of bias obtained as:$\hat{bias}_i = \frac{1}{B}\sum_{b=1}^{B} \hat{\theta}_{i,b}^* - \hat{\theta}_i$.

5. Use the Maximum likelihood method to estimate the truncated regression of $\hat{\hat{\theta}}_i$ on z_i, providing estimates of $(\beta, \sigma_\varepsilon)$.

6. Repeat the next three steps (a–c) B_2 times to obtain a set of bootstrap estimates $\{(\hat{\hat{\theta}}_b^*, \hat{\hat{\sigma}}_b^*, b = 1, ...B_2)\}$.

   (a) For i = 1, ... , n, ε_i is drawn from $N(0, \hat{\hat{\sigma}}$ with left truncation at $(1 - \hat{\hat{\beta}} z_i)$.

   (b) For i = 1, ... , n, compute $\theta_i^{**} = \hat{\hat{\beta}} z_i + \varepsilon_i$.

   (c) The Maximum likelihood method is again used to estimate the truncated regression of θ_i^{**} on z_i, providing estimates $(\hat{\hat{\beta}}^*, \hat{\hat{\sigma}}^*)$.

7. Use the bootstrap results to construct confidence intervals and standard errors.

In this study, the bank characteristics, macroeconomic conditions, financial development and market structure would be used.

$$\begin{aligned} \hat{\theta}_{it}^* = \beta_0 + \beta_1 LOGTA_{it} + \beta_2 EQASS_{it} + \beta_3 NPL_{it} \\ + \beta_4 ROE_{it} + \beta_5 LOANTA_{it} + \epsilon_{it} \end{aligned} \tag{2.23}$$

where $\hat{\theta}_{it}^*$ is the technical efficiency of the i_{th} bank obtained in period t using Simar and Wilson (2007) Bootstrap.The first model would be using bank characteristics. The bank specific variables are: LOGTA is the logarithm of bank's assets and controls for bank's size; NPL is loan loss provisions over total loans and is a measure of Asset Quality; ROE is the pre-tax profit divided by equity; EQASS is equity to assets ratios and is measure for the capital strength

of the bank and LOANTA is total loans over total assets and is a measure of loan activity. These variable have been used in the past studies to reveal the bank specific characteristics which have an impact on the efficiency (Pasiouras, 2008b; Pasiouras et al., 2006).

$$\begin{aligned}\hat{\theta}^{*}_{it} = \beta_0 + \beta_1 LOGTA_{it} + \beta_2 EQASS_{it} + \beta_3 NPL_{it} \\ + \beta_4 ROE_{it} + \beta_5 LOANTA_{it} + \beta_6 GDPGR_{it} + \epsilon_{it}\end{aligned} \tag{2.24}$$

where $\hat{\theta}^{*}_{it}$ is the technical efficiency of the i_{th} bank obtained in period t using Simar and Wilson (2007) Bootstrap. The second model would be using bank characteristics and macroeconomic conditions. Earlier studies have used different variables for controlling the macroeconomic conditions. In this study, for annual growth in GDP is used for controlling the macroeconomic condition. Earlier studies have found that the favourable conditions would be affecting positively the demand of supply of banking services and would possibly contribute towards an improvement in the bank's efficiency.Maudos et al. (2002) found that the banks operating in expanding markets proxy by the real growth rate of GDP present higher levels of profit efficiency. However, under expansive demand conditions, banks would feel less pressurised to control their costs and could be less cost efficient.Boyd et al. (2001) found that that countries with high inflation have underdeveloped financial systems and banks. Moreover, Grigorian and Manole (2006) and Pasiouras (2008b) found that inflation has no significant relationship between inflation and bank efficiency.

$$\begin{aligned}\hat{\theta}^{*}_{it} = \beta_0 + \beta_1 LOGTA_{it} + \beta_2 EQASS_{it} + \beta_3 NPL_{it} + \beta_4 ROE_{it} \\ + \beta_5 LOANTA_{it} + \beta_6 ASSGDP_{it} + \beta_7 CLAIMS_{it} + \epsilon_{it}\end{aligned} \tag{2.25}$$

where $\hat{\theta}^{*}_{it}$ is the technical efficiency of the i_{th} bank obtained in period t using Simar and Wilson (2007) Bootstrap.The third model would be incorporating both bank characteristics and financial development. Numerous studies have found that overall financial development, measured by banking market size and levels of monetarization contributes to higher efficiency. In this study, these two variables are used for controlling for the development of the financial sector. These measures have been used in the studies of Demirgüç-Kunt and Huizinga (1999) ,Pasiouras (2008b) and Caprio et al. (2008). The banking market size is calculated by dividing Assets of deposit money banks with GDP. The monetarization is calculated by dividing Bank claims to the private sector

with GDP.

$$\begin{aligned}\hat{\theta}^{*}_{it} = \beta_0 + \beta_1 LOGTA_{it} + \beta_2 EQASS_{it} + \beta_3 NPL_{it} \\ + \beta_4 ROE_{it} + \beta_5 LOANTA_{it} + \beta_6 CONC_{it} + \epsilon_{it}\end{aligned} \tag{2.26}$$

where $\hat{\theta}^{*}_{it}$ is the technical efficiency of the i_{th} bank obtained in period t using Simar and Wilson (2007) Bootstrap. Model 4 would be including bank characteristics and market structure.The study also controls for differences in the market structure among countries. This is done by using the degree of concentration. Earlier studies have found that less concentrated markets have a higher efficiency.Nicoló et al. (2004) found that highly concentrated banking systems exhibit levels of systemic risk potential higher than less concentrated systems during the period 1993–2000,and this relationship strengthened during the 1997–2003 period.This measure has been used in the studies of Pasiouras (2008b) and Beck et al. (2006). This is measured as the percentage of assets held by the three largest commercial banks in the country.

$$\begin{aligned}\hat{\theta}^{*}_{it} = \beta_0 + \beta_1 LOGTA_{it} + \beta_2 EQASS_{it} + \beta_3 NPL_{it} + +\beta_4 ROE_{it} \\ + \beta_5 LOANTA_{it} + \beta_6 GDPGR_{it} + \beta_7 ASSGDP_{it} \\ + \beta_8 CLAIMS_{it} + \beta_9 CONC_{it} + \epsilon_{it}\end{aligned} \tag{2.27}$$

Model 5 would be incorporating bank characteristics, macroeconomic conditions, financial development, and market structure.

This model would be incorporating bank characteristics, macroeconomic conditions, financial development, and market structure.

2.4.4 Data

The focus is on the commercial banks because it would allow us to examine a more homogeneous sample in terms of services and consequently inputs and outputs enhancing further the comparability among countries. The study concentrates on the banks in 15 countries in Europe with the financial data available from Market Intelligence for the period 2008-2015. The banks were excluded from the sample for one of the following reasons: - (i) they had no data available for any of the years, (ii) they had missing or negative values for the required inputs/outputs, and (iii) they had missing values for the bank-

specific control variables. By following this procedure,we have 194 banks in 15 countries in Europe for the period 2008-2015 in the final sample.

The EBA capital exercise was implemented across Europe.The EBA disclosed the results of the capital exercise for only 61 banks.In this study, we have 46 banks out of 61 banks from EU-15 countries who's results were disclosed by the EBA. The results of the banks announced by EBA have been classified as CEB (Capital Exercise Bank) and the others have been classified as Non-CEB.The sample of 194 banks is divided into 2 sub-samples based on the above classification.The sample of CEB has 46 banks and the sample of Non-CEB has 148 banks.

During the above procedure, we select the consolidated data only. The reports prepared under International Financial Reporting Standards are used where available, but if only reports prepared under local generally accepted accounting principles are available, then it is used. All the data was converted to the Euro before downloading, using the official exchange rates available in Market Intelligence. The country-specific variable is downloaded from the World Bank.

2.5 Results

2.5.1 Descriptive Statistics

Table 2.3 shows the descriptive statistics for the inputs and outputs. From 2008 to 2015, the deposits and the equity are increasing. Both are increasing over the time. However, the interest expenses and the non-interest expenses are both decreasing. But, the interest expenses have decreased tremendously over the time while the non-interest expenses have decreased but not as much as compared to the interest expenses. Loans and Non-interest income have increased over the time. However, the other earning assets have decreased from 2008 to 2015.

Tables 2.4 and 2.5 shows the descriptive statistics for the bank characteristics, macroeconomic conditions, financial development and market structure. From 2008 to 2015, EQASS which measures capital strength has increased. Moreover, ROE has increased tremendously over time, which shows that profitability of the bank. However, NPL, LOANTA and LOGTA have diminished

from 2008 to 2015. ASSGDP has diminished from 2008 to 2015. Additionally, CONC has increased slightly from 2008 to 2015. The financial development variables have negligible change from 2008 to 2015.

Table 2.2: Description of control variables used in the Double Bootstrap Truncated regression model.

Variable	**Description**	**Remarks**
Bank Characteristics		
LOGTA	Logarithm of total assets	Size
NPL	Loan loss provisions over total loans	Asset Quality
ROE	Pre-tax profit divided by equity	Profitability
EQASS	Equity to Assets	Capital Strength
LOANTA	Total loans over total assets	Loan Activity
Macroeconomic Conditions		
GDPGR	Real GDP growth	Overall economic condition
Financial Development		
ASSGDP	Assets of deposit money banks/GDP	Size of the banking system
CLAIMS	Bank claims to the private sector/GDP	Activity in the banking sector
Market Structure		
CONC	Percentage of assets held by the three largest commercial banks in the country	Concentration

Table 2.3: Descriptive Statistics for the Inputs and the Outputs variables for Bootstrap DEA.The input variables are :-Deposit,Equity,Interest Expenses and Non-Interest Expenses.The output variables are :- Loan,Non-Interest Income and Other Earning Assets.The sample period is 2008-2015.The sample consist of 194 banks in each year.Statistics of mean and standard deviation are reported.The figures are reported in €millions.

Variable	2008	2009	2010	2011	2012	2013	2014	2015
Deposit								
Mean	52,400	53,100	55,000	56,300	59,500	58,500	61,600	65,000
S.D.	134,000	134,000	138,000	142,000	148,000	145,000	157,000	166,000
Equity								
Mean	5,349.452	6,761.916	7,283.694	7,169.484	7,536.249	7,560.048	8,239.445	8,606.792
S.D.	13,300	16,700	17,800	18,200	19,100	18,500	20,900	22,000
Int.Exp								
Mean	4,666.960	2,844.893	2,327.744	2,463.533	2,371.708	1,889.525	1,645.910	1,484.753
S.D.	13,000	8,149.185	6,407.363	6,545.241	6,098.041	4,730.433	4,293.166	4,036.147
Non Int.Exp								
Mean	1,953.227	1,934.418	2,001.219	1,973.271	1,940.402	1,867.585	1,808.732	1,927.158
S.D.	6,314.649	5,545.554	5,554.227	5,210.248	5,128.914	4,921.805	4,781.882	5,222.499
Loan								
Mean	64,300	66,800	68,700	67,500	66,400	63,300	65,000	67,100
S.D.	150,000	155,000	155,000	155,000	151,000	144,000	151,000	157,000
Non-Int.Income								
Mean	1,057.409	1,323.670	1,387.369	1,142.897	1,175.542	1,214.294	1,139.254	1,245.262
S.D.	4,634.710	4,157.407	4,220.948	4,026.918	3,378.774	3,471.395	3,167.228	3,522.942
OEA								
Mean	117,000	106,000	110,000	113,000	112,000	103,000	109,000	104,000
S.D.	397,000	337,000	348,000	364,000	359,000	329,000	349,000	332,000

Table 2.4: Descriptive Statistics for the control variables before the Capital Exercise.The sample period is 2008- 2011.The sample consists of 194 banks for each year.Statistics of mean,standard deviation, minimum and maximum are reported.

VARIABLE	**MEAN**	**S.D.**	**MIN**	**MAX**
LOGTA	16.28	2.623	10.28	21.53
EQASS	0.079	0.090	-0.305	0.976
NPL	7.725	8.455	0.821	37.81
LOANTA	0.647	0.192	0.000	0.889
ROE	-13.70	220.9	-2956.6	41.15
GDPGR	1.826	1.719	-0.356	9.512
ASSGDP	88.75	48.97	47.02	380.3
CLAIMS	110.2	34.81	51.36	247.9
CONC	65.26	13.11	34.70	90.79

Table 2.5: Descriptive Statistics for the control variables after the Capital Exercise.The sample period is 2012- 2015.The sample consists of 194 banks for each year.Statistics of mean,standard deviation, minimum and maximum are reported.

VARIABLE	**MEAN**	**S.D.**	**MIN**	**MAX**
LOGTA	15.83	2.720	10.43	21.58
EQASS	0.087	0.043	-0.019	0.272
NPL	7.616	8.117	0.82	37.81
LOANTA	1.453	0.212	1.17	1.845
ROE	0.628	0.186	0.036	0.921
GDPGR	2.880	22.80	-162.2	185.7
ASSGDP	88.57	47.28	53.42	380.3
CONC	110.2	34.05	51.36	247.9
CONC	65.95	12.96	34.70	90.79

Table 2.6: Descriptive Statistics of banks based on their country for the control variables used in Simar and Wilson (2007)'s Double Bootstrap Truncated regression model before the Capital Exercise.The sample period is 2008- 2011.The sample consists of 194 banks for each year in 15 EU countries.Statistics of mean,standard deviation, minimum and maximum are reported.

Country		**LOGTA**	**EQASS**	**LOANTA**	**NPL**	**ROE**	**ASSGDP**	**CLAIMS**	**CONC**	**GDPGR**
Austria	MEAN	14.34	0.058	0.830	5.558	2.408	78.400	84.694	60.418	1.100
	S.D	0.803	0.017	0.050	2.361	3.745	0.000	0.000	0.000	0.000
	MIN	12.9	0.049	0.740	2.190	0.060	78.400	84.694	60.418	1.100
	MAX	14.72	0.089	0.857	7.630	7.970	78.400	84.694	60.418	1.100
Belgium	MEAN	21.37	0.022	0.174	2.390	4.193	108.403	59.308	61.882	1.430
	S.D	0.176	0.005	0.038	0.753	10.747	0.000	0.000	0.000	0.000
	MIN	21.12	0.014	0.122	1.540	-10.940	108.403	59.308	61.882	1.430
	MAX	21.51	0.026	0.213	3.310	14.190	108.403	59.308	61.882	1.430
Cyprus	MEAN	17.72	0.061	0.691	5.445	3.785	175.044	247.982	75.387	1.960
	S.D	0.053	0.001	0.017	1.588	4.385	0.000	0.000	0.000	0.000
	MIN	17.68	0.06	0.676	3.660	1.450	175.044	247.982	75.387	1.960
	MAX	17.79	0.064	0.715	7.460	10.360	175.044	247.982	75.387	1.960
Denmark	MEAN	19.79	0.04	0.615	4.932	6.850	53.486	170.751	81.455	2.340
	S.D	1.409	0.012	0.141	2.173	5.886	0.000	0.000	0.000	0.000
	MIN	16.95	0.022	0.369	2.020	-5.850	53.486	170.751	81.455	2.340
	MAX	21.53	0.064	0.825	8.180	15.980	53.486	170.751	81.455	2.340
France	MEAN	16.05	0.11	0.812	8.105	6.041	76.788	93.580	57.467	1.030
	S.D	1.166	0.017	0.059	10.085	2.233	0.000	0.000	0.000	0.000
	MIN	12.53	0.069	0.664	1.060	-3.380	76.788	93.580	57.467	1.030
	MAX	17.32	0.147	0.889	43.210	8.410	76.788	93.580	57.467	1.030
Germany	MEAN	13.25	0.079	0.655	20.821	1.519	82.788	114.850	76.735	-0.350
	S.D	1.43	0.045	0.089	15.025	3.875	0.000	0.000	0.000	0.000
	MIN	10.28	0.036	0.487	3.430	-9.430	82.788	114.850	76.735	-0.350
	MAX	15.46	0.226	0.803	45.760	7.860	82.788	114.850	76.735	-0.350
Italy	MEAN	18.24	0.057	0.537	4.661	4.297	78.029	87.415	62.911	0.800
	S.D	2.704	0.015	0.188	4.618	14.182	0.000	0.000	0.000	0.000
	MIN	14.09	0.028	0.261	1.640	-23.660	78.029	87.415	62.911	0.800
	MAX	21.45	0.089	0.865	15.300	29.030	78.029	87.415	62.911	0.800
Luxembourg	MEAN	17.45	0.069	0.408	4.538	6.428	380.388	91.237	34.709	3.930
	S.D	0.027	0.006	0.056	1.556	2.462	0.000	0.000	0.000	0.000
	MIN	17.43	0.06	0.339	2.440	4.180	380.388	91.237	34.709	3.930
	MAX	17.49	0.074	0.465	6.120	9.080	380.388	91.237	34.709	3.930
Malta	MEAN	13.17	0.075	0.591	6.885	4.727	142.993	88.432	90.790	9.510
	S.D	0.03	0.002	0.014	0.276	1.291	0.000	0.000	0.000	0.000
	MIN	13.14	0.072	0.575	6.560	3.240	142.993	88.432	90.790	9.510
	MAX	13.21	0.078	0.606	7.230	5.570	142.993	88.432	90.790	9.510
Netherlands	MEAN	18.94	0.04	0.612	6.520	0.436	101.371	114.604	85.506	1.960
	S.D	1.593	0.007	0.143	1.826	8.622	0.000	0.000	0.000	0.000
	MIN	16.64	0.031	0.433	3.380	-19.960	101.371	114.604	85.506	1.960
	MAX	20.55	0.052	0.787	7.920	8.520	101.371	114.604	85.506	1.960
Poland	MEAN	14.29	0.12	0.569	4.790	7.943	53.597	51.926	41.977	3.840
	S.D	1.469	0.054	0.075	1.029	3.918	0.000	0.000	0.000	0.000
	MIN	12.81	0.063	0.491	3.860	3.760	53.597	51.926	41.977	3.840
	MAX	15.7	0.18	0.690	5.740	14.160	53.597	51.926	41.977	3.840
Portugal	MEAN	17.1	0.068	0.749	2.668	3.757	80.182	122.345	88.426	1.820

Table 2.6 – *Continued from previous page*

Country		LOGTA	EQASS	LOANTA	NPL	ROE	ASSGDP	CLAIMS	CONC	GDPGR
	S.D	0.864	0.029	0.026	0.381	1.742	0.000	0.000	0.000	0.000
	MIN	16.37	0.027	0.718	2.190	1.120	80.182	122.345	88.426	1.820
	MAX	18.15	0.094	0.796	3.120	5.910	80.182	122.345	88.426	1.820
Slovakia	MEAN	15.27	0.074	0.732	8.598	-6.045	51.828	56.525	55.711	2.638
	S.D	0.077	0.014	0.036	6.378	20.967	3.203	10.318	1.145	0.405
	MIN	15.17	0.054	0.708	2.410	-37.270	47.024	51.366	53.993	2.030
	MAX	15.33	0.086	0.787	16.380	6.350	53.429	72.001	56.283	2.840
Spain	MEAN	15.51	0.086	0.504	9.665	-115.718	95.604	121.581	58.389	3.650
	S.D	2.13	0.234	0.287	9.205	592.351	0.000	0.000	0.000	0.000
	MIN	12.12	-0.305	0.000	2.560	-2956.670	95.604	121.581	58.389	3.650
	MAX	19.42	0.976	0.744	36.410	41.150	95.604	121.581	58.389	3.650
United Kingdom	MEAN	15.99	0.069	0.674	5.341	-28.606	132.976	132.976	51.449	2.350
	S.D	2.694	0.029	0.028	1.115	82.890	0.000	0.000	0.000	0.000
	MIN	13.41	-0.002	0.639	3.860	-231.400	132.976	132.976	51.449	2.350
	MAX	18.6	0.09	0.737	6.810	18.860	132.976	132.976	51.449	2.350

Table 2.7: Descriptive Statistics of banks based on their country for the control variables used in Simar and Wilson (2007)'s Double Bootstrap Truncated regression model after the Capital Exercise.The sample period is 2012- 2015.The sample consists of 194 banks for each year in 15 EU countries.Statistics of mean,standard deviation, minimum and maximum are reported.

Country		LOGTA	EQASS	LOANTA	NPL	ROE	ASSGDP	CLAIMS	CONC	GDPGR
Austria	MEAN	13.769	0.062	0.817	4.404	5.241	78.400	84.694	60.418	1.100
	S.D	0.847	0.012	0.086	1.750	6.939	0.000	0.000	0.000	0.000
	MIN	12.876	0.053	0.732	2.190	-7.030	78.400	84.694	60.418	1.100
	MAX	14.707	0.094	0.921	7.460	12.230	78.400	84.694	60.418	1.100
Belgium	MEAN	21.273	0.036	0.233	1.125	-1.300	108.403	59.308	61.882	1.430
	S.D	0.103	0.007	0.027	0.417	5.615	0.000	0.000	0.000	0.000
	MIN	21.200	0.027	0.197	0.830	-9.620	108.403	59.308	61.882	1.430
	MAX	21.423	0.043	0.263	1.420	2.640	108.403	59.308	61.882	1.430
Cyprus	MEAN	17.604	0.071	0.677	1.188	-9.955	175.044	247.982	75.387	1.960
	S.D	0.086	0.013	0.069	0.253	9.004	0.000	0.000	0.000	0.000
	MIN	17.539	0.059	0.576	0.840	-22.800	175.044	247.982	75.387	1.960
	MAX	17.728	0.089	0.725	1.420	-1.740	175.044	247.982	75.387	1.960
Denmark	MEAN	20.172	0.053	0.584	16.509	6.202	54.135	173.325	81.381	1.887
	S.D	1.036	0.014	0.129	15.303	5.462	2.595	10.293	0.296	1.813
	MIN	19.014	0.034	0.379	1.760	-3.130	53.486	170.751	80.271	-4.910
	MAX	21.590	0.082	0.761	43.210	14.130	63.867	211.922	81.455	2.340
France	MEAN	16.176	0.127	0.801	7.646	5.010	76.783	93.638	57.566	1.015
	S.D	1.164	0.018	0.067	10.734	1.435	0.037	0.382	0.652	0.098
	MIN	12.798	0.075	0.618	1.060	0.580	76.545	93.580	57.467	0.380
	MAX	17.441	0.162	0.879	45.760	8.410	76.788	96.114	61.791	1.030
Germany	MEAN	13.655	0.069	0.675	10.476	2.316	83.022	114.915	76.730	-0.325
	S.D	1.141	0.036	0.095	9.347	8.101	1.574	0.437	0.031	0.168
	MIN	10.908	0.037	0.454	1.760	-39.450	82.788	114.850	76.527	-0.350
	MAX	15.009	0.267	0.813	36.410	10.560	93.346	117.780	76.735	0.780
Italy	MEAN	16.974	0.101	0.374	5.769	0.199	77.909	87.707	62.904	0.673
	S.D	4.053	0.069	0.198	1.268	34.699	0.541	1.303	0.031	0.570

Table 2.7 – *Continued from previous page*

Country		LOGTA	EQASS	LOANTA	NPL	ROE	ASSGDP	CLAIMS	CONC	GDPGR
	MIN	10.434	0.045	0.036	4.220	-119.380	75.610	87.415	62.771	-1.750
	MAX	21.455	0.272	0.661	7.630	38.950	78.029	93.244	62.911	0.800
Luxembourg	MEAN	17.536	0.093	0.476	6.048	6.905	380.388	91.237	34.709	3.930
	S.D	0.025	0.007	0.016	0.755	0.318	0.000	0.000	0.000	0.000
	MIN	17.517	0.084	0.455	4.950	6.610	380.388	91.237	34.709	3.930
	MAX	17.572	0.101	0.492	6.610	7.320	380.388	91.237	34.709	3.930
Malta	MEAN	13.274	0.093	0.616	3.473	8.830	142.993	88.432	90.790	9.510
	S.D	0.060	0.008	0.022	0.332	10.564	0.000	0.000	0.000	0.000
	MIN	13.207	0.082	0.595	3.110	2.610	142.993	88.432	90.790	9.510
	MAX	13.348	0.100	0.641	3.760	24.540	142.993	88.432	90.790	9.510
Netherlands	MEAN	17.057	0.071	0.593	4.323	-8.908	101.208	114.778	85.653	1.916
	S.D	2.908	0.037	0.138	2.223	17.756	0.564	0.605	0.508	0.153
	MIN	13.374	0.037	0.400	1.540	-42.960	99.419	114.604	85.506	1.430
	MAX	20.271	0.126	0.720	7.570	4.820	101.371	116.698	87.268	1.960
Poland	MEAN	14.647	0.115	0.463	6.138	8.470	53.597	51.926	41.977	3.840
	S.D	1.357	0.045	0.077	1.979	5.470	0.000	0.000	0.000	0.000
	MIN	12.988	0.068	0.347	3.270	2.070	53.597	51.926	41.977	3.840
	MAX	16.108	0.178	0.577	7.810	14.930	53.597	51.926	41.977	3.840
Portugal	MEAN	16.362	0.097	0.790	8.053	0.700	80.914	130.643	87.447	1.840
	S.D	0.027	0.003	0.029	4.158	1.947	1.464	16.597	1.958	0.040
	MIN	16.335	0.095	0.750	1.980	-1.570	80.182	122.345	84.511	1.820
	MAX	16.396	0.102	0.817	11.290	2.930	83.110	155.539	88.426	1.900
Slovakia	MEAN	15.117	0.094	0.564	5.987	-63.440	53.429	51.366	56.283	2.840
	S.D	0.145	0.044	0.110	0.441	71.637	0.000	0.000	0.000	0.000
	MIN	14.930	0.046	0.460	5.530	-162.270	53.429	51.366	56.283	2.840
	MAX	15.277	0.144	0.702	6.410	7.930	53.429	51.366	56.283	2.840
Spain	MEAN	15.523	0.097	0.467	18.124	9.954	95.704	124.621	58.405	3.423
	S.D	2.656	0.047	0.200	16.661	12.892	0.401	12.163	0.066	0.908
	MIN	12.480	0.060	0.094	2.190	-3.880	95.604	121.581	58.389	0.020
	MAX	19.668	0.181	0.727	38.400	35.230	97.206	170.231	58.651	3.650
United Kingdom	MEAN	14.832	0.066	0.653	5.134	16.404	132.976	132.976	51.449	2.350
	S.D	2.325	0.034	0.087	2.221	52.264	0.000	0.000	0.000	0.000
	MIN	12.870	-0.019	0.408	2.220	-25.710	132.976	132.976	51.449	2.350
	MAX	18.562	0.114	0.802	7.530	185.710	132.976	132.976	51.449	2.350

Tables 2.6 and 2.7 provides the descriptive statistics for the bank characteristics, macroeconomic conditions, financial development and market structure for the EU 15 countries. On average, EQASS for the majority of the countries has declined after the announcement. However, EQASS for Germany, Poland, and the United Kingdom has increased. On average, LOGTA has increased for the majority of countries. The banks have increased in size when measured by the total assets. LOANTA has increased after the capital exercise announcement. The banks have increased their loan activity after the announcement. This has contributed to an increase in NPL on average for half of the countries. Germany has the highest NPL on average. This has doubled after the capital

exercise announcement. However, after the capital exercise announcement, the NPL of Spain has reduced by almost half. ROE on average has a mixed effect on the profitability of the banks after capital exercise. The majority of the countries have witnessed ROE of the bank's increase. However, the banks in Spain have suffered the most. They have a very high negative ROE. Additionally, the banks in the United Kingdom and Slovakia have a negative return. But, in the case of Slovakia, ROE has improved when compared before the capital announcement.

2.5.2 First Stage Bootstrap DEA Results

Table 2.8: Bootstrap DEA Results for banks under Constant Returns to Scale before the Capital Exercise and after Capital Exercise.Simar and Wilson (2000) Bootstrap DEA is used to calculating efficiency scores.The sample period for before the Capital Exercise is 2008-2011.The sample period for after the Capital Exercise is 2012-2015.The sample consists of 194 banks for each year in 15 EU countries.The reported Efficiency score is the average during the sample period in the country.

COUNTRY	Efficiency Score before Capital Exercise	Efficiency Score after Capital Exercise
Austria	0.711	0.621
Belgium	0.544	0.783
Cyprus	0.438	0.454
Denmark	0.426	0.421
France	0.496	0.464
Germany	0.413	0.432
Italy	0.543	0.464
Luxembourg	0.541	0.432
Malta	0.557	0.621
Netherlands	0.634	0.502
Poland	0.656	0.601
Portugal	0.356	0.275
Slovakia	0.568	0.554
Spain	0.467	0.443
United Kingdom	0.414	0.464
Average	0.494	0.475

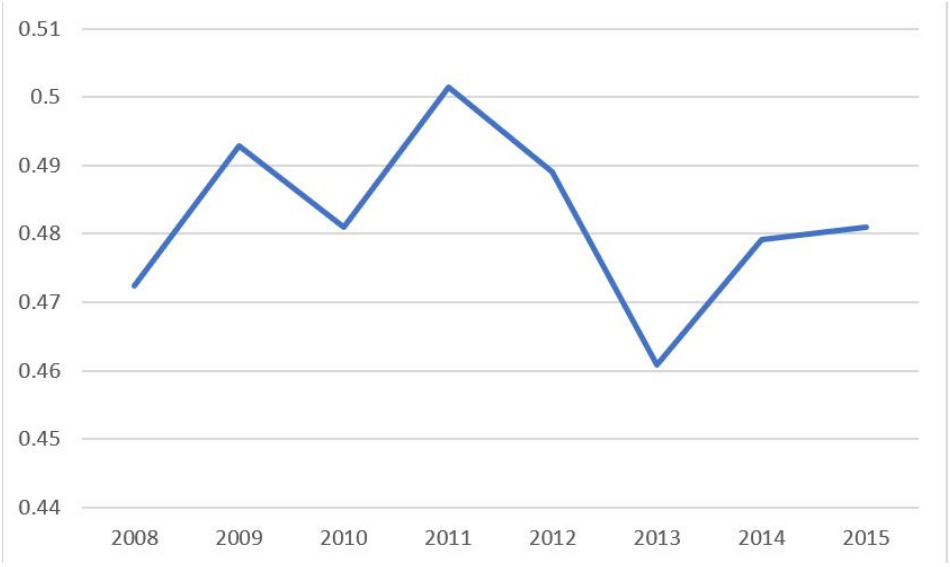
The observations for each specific bank, for each country and year, are pooled together in two samples:- 2008-2011 and 2012-2015. This is followed by running two DEA models, one for each sample. Each sample consists of 194 banks each year. In total, each sample has 776 banks. The minimum number of the banks in each country in the sample for each year is 4 and the maximum number for each year is 33.

Table 2.8 presents the results of the DEA. The panel shows the average Technical Efficiency scores of the banks that are experiencing constant returns to scale. The mean of the Technical Efficiency for the banks in the sample equal .494 and .476 for before and after the capital exercise announcement was made by the EBA respectively. Before the announcement, the average bank could improve its technical efficiency by 50.6%. But, after the announcement, the average bank could be improving its technical efficiency by 52.47%. In other words, if the average bank was producing on the frontier instead of its current location, only 40.4% of the inputs currently being used would be necessary to produce the same output vector. However, after the announcement, only 47.53% of the inputs currently being used would be necessary to produce the same output vector.

Before the Capital Exercise was announced, the most efficient countries appeared to be Austria and Poland. After the Capital Exercise is announced, the most efficient countries appeared to be Belgium and Austria. In general, the efficiency scores of the banks have changed after the announcement of the capital exercise. The efficiency scores of the banks in most of the countries have changed after the announcement. The efficiency of the banks in most of the banks has declined. Only the efficiency of the banks in Belgium, Germany, Malta, Denmark, Cyprus, and the United Kingdom have improved. However, the efficiency of the banks in Denmark after the announcement is negligible. The efficiency of the banks in Portugal has the worst efficiency scores after the capital announcement. The efficiency of the banks got worse because of the financial crisis in Portugal. The debt of Portugal kept on rising. It was only in 2014, Portugal left the EU bailout mechanism without requiring any more support.

Figure 2.1 shows the average efficiency of the banks from 2008 to 2015. The efficiency of the bank was increasing and decreasing till 2011. This could be explained by the changes in the inputs and output over the years. The inputs such as Interest Expenses and Non-Interest Expenses have been increasing and decreasing over time until 2011. The outputs are increasing and decreasing as well during this time. However, after 2011, the efficiency of the banks is decreasing until 2013. During this time, inputs such as Deposits and Costs are decreasing while the outputs such Loan and Other earning assets are decreasing

Figure 2.1: Efficiency of the banks in 15 EU countries over time under Constant Returns to Scale.Simar and Wilson (2000) Bootstrap DEA is used for calculating the efficiency scores.The sample consists of 194 banks for each year in 15 EU countries.The sample period is 2008-2015.The reported is the average Efficiency scores in the sample period.



as well. However, the efficiency scores increase from 2013. The inputs such as deposit, equity, and interest expenses are increasing whereas the outputs such as Other Earning Assets and Loans are increasing. The efficiency of the banks becomes steady from 2014 onwards. The changes in the inputs and the outputs while increasing and decreasing are not drastic. The EBA capital exercise made the banks to reconsider their activities. As a result, there was a decrease in the efficiency of the banks which lasted till 2013. However, after 2014, the efficiency of the banks has become steady which reflects the activity of the bank is steady in terms of the inputs and outputs. But, this was not the case before the 2011 capital exercise announcement.

The Global Financial Crisis hit Europe in 2008. The efficiency of the banks fell to the lowest level during this time. In the following year, the efficiency of the banks started improving. However, in 2010, the Sovereign Debt Crisis hits Europe. This has resulted in the efficiency of the banks to decrease again. After the capital exercise is announced, the efficiency of the banks has fallen. This is because the banks have to restructure their balance sheets and maintain the required targets which have been set by the EBA. The efficiency of the banks continues to fall because of the crisis in Ireland. But, in the following years, it starts to improve. This is helped by an improvement in the stock market. The EBA capital exercise requirements have helped the

bans maintain their efficiency levels in the following years. During these years, Europe was once again on the brink of recession. With Greece starting to cause panic. Furthermore, this was accompanied by inflation falling to record lows in the Eurozone and the collapse of the oil price. The EBA capital exercise requirements have contributed to allowing the banks to maintain their efficiency levels during the years of turmoil. Additionally, the inputs and outputs of the banks became steady because of the capital exercise.

2.5.3 Double Bootstrap Truncated Regression Analysis

In the second stage of the the analysis, we investigate the determinants of the technical efficiency of the banks by employing Simar and Wilson (2007)'s Bootstrap Truncated regression.This technique allows to obtain consistent and unbiased estimates in the second-stage.In Simar and Wilson (2007) Bootstrap truncated regression,the bias-corrected efficiency scores $\hat{\theta}_i^*$ yielded in the first-stage are regressed on a set of explanatory variables.F-test has been used in the study for measuring the significance of the model. The p-value of F-test is less than 5% in all the models. This shows the model is a better fit. Following Pasiouras et al. (2006) and Pasiouras (2008b), QML (Huber/White) standard errors and covariates are calculated. This is because heteroskedasticity can emerge when estimated parameters are used as dependent variables in the second stage analysis.

Controlling for bank-specific characteristics

Tables 2.9 and 2.10 presents the regression results when controlling only for bank-specific characteristics. The results provide evidence in favour of the capital exercise used by the EBA to promote the efficiency of the banks using the determinants of efficiency. Before the announcement, ROE is not having an impact on the inefficiency of the bank. After the announcement, ROE is having a negatively significant impact on the efficiency of the bank. This finding indicates that the more profitable banks have lower inefficiency. This corroborates with similar findings of the other studies (Pastor et al., 1997; Das and Ghosh, 2006). Banks that are reporting higher profitability ratios are usually preferred by the clients. Therefore, they attract the biggest share of deposits along with the best potential creditworthy borrowers. Moreover, this implies

Table 2.9: Double Bootstrap Truncated Regression results before capital exercise. Model 1 controls for the bank characteristics. Model 2 controls for bank characteristics and Macroeconomic Conditions. Model 3 controls for bank characteristics and financial development. Model 4 controls for bank characteristics and Market structure. Model 5 controls for bank characteristics, macroeconomic conditions, financial development and market structure.The sample consists of 194 banks for each year for the period 2008-2011. QML (Huber/White) standard errors and covariates have been calculated to control for heteroscedacity, (***statistically significant at 1% level, **Statistically significant at 5% level, *Statistically significant at 10% level)

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
BANK CHARACTERISTICS					
LOGTA	-0.006	-0.005	-0.003	-0.006	-0.002
	(1.78)*	(1.86)*	(1.02)	(2.00)**	(1.12)
EQASS	-0.401	-0.502	-0.621	-0.644	-0.745
	(1.81)*	(1.82)*	(1.88)*	(2.17)**	(2.31)**
LOANTA	0.008	0.046	0.034	0.003	0.070
	(0.20)	(1.10)	(0.74)	(0.10)	(.55)
NPL	-0.002	-0.003	-0.004	-0.004	-0.004
	(2.62)***	(2.17)**	(3.04)***	(2.54)**	(2.44)**
ROE	0.007	0.008	0.007	0.007	0.006
	(1.62)	(1.66)*	(2.76)***	(2.22)**	(4.60)***
MACROECONOMIC CONDITIONS					
GDPGR		0.013			0.023
		(2.25)**			(3.50)***
FINANCIAL DEVELOPMENT					
ASSGDP			0.005		0.003
			(3.45)***		(1.51)
CLAIMS			-0.002		-0.001
			(5.04)***		(3.37)***
MARKET STRUCTURE					
CONC				-0.002	-0.001
				(1.56)	(1.24)
CONSTANT	0.662	0.607	0.710	0.740	0.763
	(7.76)***	(7.29)***	(7.98)***	(7.81)***	(6.55)***
R2	0.20	0.21	0.24	0.29	0.21
LOGLIKELIHOOD	136.31	139.281	141.132	133.215	148.831
OBSERVATIONS	776	776	776	776	776

that the banks might be having a higher ROE by either having higher leverage (debt) or higher risk-taking. The capital exercise has aimed to reduce these activities of the banks. As a result, these conditions create a favourable environment for profitable banks to be more efficient from the point of view of their intermediation activities. Before and after the capital exercise, NPL is having

Table 2.10: Double Bootstrap Truncated Regression results after capital exercise. Model 1 controls for the bank characteristics. Model 2 controls for bank characteristics and Macroeconomic Conditions. Model 3 controls for bank characteristics and financial development. Model 4 controls for bank characteristics and Market structure. Model 5 controls for bank characteristics, macroeconomic conditions, financial development and market structure.The sample consists of 194 banks for each year for the period 2012-2015. QML (Huber/White) standard errors and covariates have been calculated to control for heteroscedacity (***Statistically significant at 1% level, **Statistically significant at 5% level, *Statistically significant at 10% level)

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
BANK CHARACTERISTICS					
LOGTA	0.001	0.002	0.011	0.001	-0.003
	(0.16)	(0.5)	(2.28)**	(0.07)	(0.248)
EQASS	0.754	0.582	0.394	0.495	-0.249
	(2.84)***	(2.45)**	(1.14)	(1.53)	(0.59)
LOANTA	-0.661	-0.581	-0.542	-0.650	-0.628
	(8.25)***	(6.82)***	(7.18)***	(7.17)***	(6.89)***
NPL	-0.002	-0.001	-0.003	-0.002	-0.002
	(3.18)***	(3.15)***	(0.28)	(2.40)**	(1.14)
ROE	-0.001	-0.001	-0.001	-0.001	-0.002
	(1.78)*	(2.09)**	(2.08)**	(2.28)**	(3.17)***
MACROECONOMIC CONDITIONS					
GDPGR		0.014			0.017
		(2.78)***			(2.51)**
FINANCIAL DEVELOPMENT					
ASSGDP			0.001		0.005
			(3.28)***		(5.14)***
CLAIMS			-0.001		0.002
			(2.23)**		(2.88)***
MARKET STRUCTURE					
CONC				-0.002	-0.010
				(1.19)	(4.91)***
CONSTANT	0.838	0.747	0.500	0.809	0.987
	(7.50)***	(7.43)***	(3.40)***	(6.42)***	(5.10)***
R2	0.380	0.375	0.411	0.323	0.381
LOGLIKELIHOOD	113.21	121.29	124.34	129.31	139.37
OBSERVATIONS	776	776	776	776	776

a highly negative significant impact on inefficiency. This is consistent with the earlier finding by among other, Kwan et al. (1995); Resti (1997). These results imply that the banks should be focusing on credit risk management, which has been proven to be problematic in the past. Serious banking problems have arisen from the failure of the banks to recognise impaired assets and create

reserves for writing off these assets.

Before the announcement, EQASS exhibits a negative relationship with bank efficiency. The findings imply that the more efficient banks, use less equity compared to its peers. The results seem to suggest that the less efficient banks could have been involved in riskier operations and the process tends to hold more equity, voluntarily or involuntarily, i.e., the reason might be banks' deliberate efforts to increase safety cushions and in turn decrease the cost of funds or perhaps regulatory pressures that mandate riskier banks to carry more equity. However, after EQASS has a significant positive impact on efficiency. By having a higher capital, the EBA has aimed in improving the confidence of depositors in the bank's security. Additionally, it would be creating an environment for careful lending and better bank performances. It would be reducing the likelihood of financial distress faced by the banks (Pasiouras et al., 2009).LOANTA has a significantly negative impact on the technical efficiency of the bank. This is in line with the findings of Havrylchyk (2006)who found a negative relationship between LOANTA and efficiency. This ratio is considered as a proxy for Liquidity risk. Therefore, a negative relationship could indicate that less efficient banks are also less liquid.

Before the capital exercise occurred, EQASS and NPL have a negative correlation with the efficiency of the bank. A 1% increase in bank efficiency would require the bank's EQASS to reduce by 1.31%.Similarly, a 1% increase in bank efficiency would require the bank's NPL to reduce by 4.72%.After the Capital Exercise, EQASS has a positive correlation with efficiency. This means that to increase bank efficiency by 1%, the bank would be required to improve EQASS by 1.28%. This reflects the significance of the contribution of capital strength towards bank efficiency. Furthermore, a 2.84% decrease in NPL would be contributing to a 1% increase in efficiency. LOANTA is having a negative impact after the capital exercise on bank efficiency. These results indicate that the capital exercise is influencing the quantity and quality of lending made by the banks and the decision of the banks when allocating their asset portfolios. Therefore, Capital Exercise would be affecting the efficiency of the bank. These findings are in line with the findings of Barth et al. (2013b) who found that the capital regulations have a significant role to play in relation to the incentives of the banks with depositors and other creditors. Additionally, capital regulation

would be contributing to having less non-performing loans. Moreover, the capital requirements by the EBA would be reducing the likelihood of financial distress. As the balance sheet of the bank is getting more inclined towards liquidity than lower return assets (Pasiouras et al., 2009).

The EBA announcement has contributed towards the bank getting engaged in more profitable activities. As a result, they would be able to attract the best potential creditworthy borrowers who would be able to meet the obligations. This could be resulting in banks having less loan loss. Moreover, these conditions would be creating an environment for the banks to become more profitable and efficient.

Controlling for Macroeconomic Conditions

Tables 2.9 and 2.10 shows the regression results when controlling for the macroeconomic conditions. The growth of the GDP in the model affects the other bank-specific variables. Before the announcement of the capital exercise was made, GDPGR does have a significant impact on the technical efficiency of the banks.

However, after the capital exercise announcement, GDPGR has a statistically significant impact on technical efficiency. This indicates that favourable economic conditions affect the extent, depth, and quality of financial intermediation and banking services. This contributes to making financial institutions more efficient. Furthermore, by having a higher growth rate, it would be easier for the debtors to meet their obligations. The other variables having a significant impact on the efficiency are EQASS, LOANTA, NPL, and ROE.

Before the capital exercise, GDPGR was positively correlated with efficiency. This meant that to increase the bank efficiency by 1%, the bank would be required to reduce GDPGR by .68%. After the Capital Exercise, the magnitude of GDPGR is positive. This means that to increase bank efficiency by 1%, the bank would be required to improve GDPGR by .55%. This reflects the significance of the contribution of the real GDP growth towards bank efficiency. After capital exercise, there is a marginal decrease in the contribution of GDPGR towards bank efficiency. However, the results reflect the significance of favourable economic conditions towards the banking activity (Chortareas et al., 2011). This would be making the bank more efficient.

Controlling for financial development

The regression results indicate that after controlling for financial development before the capital announcement, CLAIMS and ASSGDP are having a significant impact on the efficiency. Both CLAIMS and ASSGDP continue to have a significant impact after the capital exercise. The results show that both the activity in the market and the size of the market have an impact on efficiency. CLAIMS has a negative impact while ASSGDP has a positive impact on efficiency. The capital regulations influence the decision of the banks regarding the mix of deposits and equity. The deposits and equity bears different costs for the bank. Furthermore, the capital requirements would be leading to careful lending and better performance. The results indicate that the capital requirements would be reducing the bank risk, but not be a highly significant benefit for the efficiency gains. When the capital regulations are placed, the banks are looking to substitute the loans with alternative forms of assets. The banks are looking for different asset portfolios which would be generating better returns and requires the different resources to be managed. Additionally, the capital requirement of the EBA would be preventing the banks from excessive risk-taking. It would be requiring the banks for different asset portfolios which would be generating better returns and require the different resources to be managed. Furthermore, it would be contributing towards the banks having a decline in non-performing loans(Berger and DeYoung, 1997). The EBA capital announcement has made the banks consider their activity in the banking sector and to manage their portfolios. As a result, the banks would be having less likelihood of having financial distress.

Controlling for market structure

The results when controlling for the market structure are quite similar to the results when controlling for financial development. CONC does not have any significant impact on the efficiency of the bank before and after the capital announcement. However, after the announcement, LOANTA and NPL have a negatively significant impact while ROE has a positive significant impact on the efficiency of the bank.

Before the capital exercise, the CONC was negatively correlated with the efficiency of the bank. This meant that to increase the bank efficiency by

1%, the bank would be required to reduce CONC by 8%. After the Capital Exercise, CONC is still negatively correlated with the efficiency of the bank. This means that to increase bank efficiency by 1%, the bank would be required to improve CONC by 3.78%. This reflects the contribution of the EBA capital exercise towards the efficiency of the bank. Additionally, less concentrated markets are associated with an increase in efficiency.

Controlling for all the variables

When controlling for Bank characteristics, Macroeconomic conditions, Financial Development, and Market Structure, the results before the announcement are quite similar to the results of controlling for market structure. However, the results changes after the announcement. GDPGR, ASSGDP, and CLAIMS are statistically significant and positively related to the technical efficiency of the bank. ROE is negatively significant to the technical efficiency of the bank.However, LOANTA and CONC have a significantly negative impact on the efficiency of the bank. LOANTA is a proxy for liquidity. If the bank is having a higher loan to assets ratio, then it would be having less liquidity. Also, less concentrated markets are associated with higher efficiency. The regression results indicate that CONC is statistically significant and negatively related to technical efficiency. This shows that the less concentrated markets are associated with increased efficiency. This is consistent with the results of (Pasiouras, 2008a). The high concentrated banking systems exhibit levels of systemic risk potential higher than the less concentrated systems during the period 1993-2000 and this relationship was strengthened during the 1997-2003 period (Nicoló et al., 2004).Pasiouras et al. (2006) reported a negative relationship between concentration and bank's overall performance and soundness as measured by Fitch ratings.

Before the capital exercise, the magnitude of EQASS was negative. This meant that to increase the bank efficiency by 1%, the bank would be required to reduce EQASS by 1.28%. The bank efficiency would be improved by 1% if the bank reduces NPL by 4.48%. GDPGR, CLAIMS, and CONC have economic significance on the efficiency of the bank. After the Capital Exercise, the magnitude of EQASS is positive. But, it is not having economic significance on the efficiency of the bank. LOANTA, NPL, and CONC are negatively

economic significant on the efficiency of the bank while CLAIMS is positively economic significant. The results indicate that the capital exercise would be creating favourable economic conditions. The banks would be becoming more involved in more careful lending. Additionally, the decision of the banks would be influenced when allocating their asset portfolios. The banks would be looking at different asset portfolios which would be generating better returns and requiring different resources to be managed. Capital regulation would be contributing to banks having fewer non-performing loans. The results indicate that the capital exercise would be preventing banks from moral hazard incentives. This is in line with the findings of Berger and DeYoung (1997) who found that the banks with more capital would be involved in lower portfolio risk-taking. This shows higher capital requirements would be contributing towards lower non-performing loans. This would be leading towards an increase in the efficiency of the bank.

The EBA's capital announcement has aimed to make the banking market less concentrated. This would be contributing to having banks less prone to potential systemic risk. Furthermore, it would be improving the overall performance of the banks and the soundness of the banks The EBA announcement has contributed towards the banks to increase their efficiency by careful lending practices. This would be improving their overall performance and prevent the banks from potential systemic risk.

2.6 Results - Bank level

2.6.1 Descriptive Statistics

Tables 2.11 and 2.12 shows the descriptive statistics for the inputs and outputs for Non- CEB, and CEB before the capital exercise took place. For Non-CEB and CEB, the inputs and outputs are constantly increasing and decreasing over the years. The EBA selected the banks for the exercise based on their size. From the table, before the capital exercise took place. The inputs and outputs of the CEB are larger than the Non- CEB.

Tables 2.13 and 2.14 shows the descriptive statistics for the inputs and outputs for Non- CEB, and CEB after the capital exercise took place. For

Table 2.11: Descriptive Statistics for Inputs and outputs used in Bootstrap DEA for Non-CEB before the Capital Exercise.Bootstrap DEA is used for calculating efficiency scores.The input variables are :-Deposit,Equity,Interest Expenses and Non-Interest Expenses.The output variables are :- Loan,Non-Interest Income and Other Earning Assets.The sample period is 2008-2011.The sample consist of 148 banks in each year.Statistics of mean and standard deviation are reported.The figures are reported in €millions.

Variables	**2008**		**2009**		**2010**		**2011**	
NON-CEB	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Deposits	20900	37800	20800	37800	20600	37200	20900	39400
Equity	2516.232	2612.444	2435.469	2585.349	2350.805	2447.930	2409.876	2852.173
Interest Expenses	0.930	2170.977	1091.201	2836.997	0.965	2304.012	852.822	2201.917
Non-Interest Expenses	0.494	0.653	0.474	0.623	499.635	0.688	0.491	0.706
Non-Interest Income	0.370	0.507	294.139	0.455	0.290	0.436	0.308	0.513
Other Earning Assets	13100	23500	13200	23800	13600	25400	12800	24300
Loans	78900	179000	98200	219000	97000	220000	93200	219000

Table 2.12: Descriptive Statistics for Inputs and outputs used in Bootstrap DEA for CEB before the Capital Exercise.Bootstrap DEA is used for calculating efficency scores.The input variables are :-Deposit,Equity,Interest Expenses and Non-Interest Expenses.The output variables are :- Loan,Non-Interest Income and Other Earning Assets.The sample period is 2008-2011.The sample consist of 46 banks in each year.Statistics of mean and standard deviation are reported.The figures are reported in €millions.

Variables	**2008**		**2009**		**2010**		**2011**	
CEB	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Deposits	190000	250000	188000	239000	194000	228000	209000	261000
Equity	24500	30400	26900	33700	27400	30700	27600	34400
Interest Expenses	4259.338	5146.766	4245.831	4995.816	4964.245	4836.266	4083.917	5211.230
Non-Interest Expenses	8180.886	11500	7954.054	11000	8288.351	10800	8222.749	11100
Non-Interest Income	4658.644	7325.528	4921.052	7466.418	4861.012	7345.391	4991.677	7442.210
Other Earning Assets	454000	772000	484000	819000	480000	817000	485000	819000
Loans	173000	298000	162000	276000	148000	246000	151000	247000

Table 2.13: Descriptive Statistics for Inputs and outputs used in Bootstrap DEA for Non-CEB after the Capital Exercise.Bootstrap DEA is used for calculating Efficiency scores.The input variables are :-Deposit,Equity,Interest Expenses and Non-Interest Expenses.The output variables are :- Loan,Non-Interest Income and Other Earning Assets.The sample period is 2012-2015.The sample consist of 148 banks in each year.Statistics of mean and standard deviation are reported.The figures are reported in €millions.

Variables	**2012**		**2013**		**2014**		**2015**	
NON-CEB	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Deposits	22200	44600	21600	38000	22300	38500	20100	35800
Equity	2619.223	3340.412	2471.095	2493.578	2521.247	2505.462	2381.160	2668.032
Interest Expenses	0.834	2023.811	1139.211	2841.089	0.974	2400.068	1158.160	3453.613
Non-Interest Expenses	466.023	0.688	0.485	0.592	0.455	0.641	0.475	0.615
Non-Interest Income	0.290	0.384	0.314	0.435	0.235	0.293	0.315	0.541
Other Earning Assets	12400	22700	13900	24400	14400	26300	13600	26500
Loans	79200	202000	73800	191000	77300	197000	71100	187000

Table 2.14: Descriptive Statistics for Inputs and outputs used in Bootstrap DEA for CEB after the Capital Exercise.Bootstrap DEA is used for calculating Efficiency scores.The input variables are :-Deposit,Equity,Interest Expenses and Non-Interest Expenses.The output variables are :- Loan,Non-Interest Income and Other Earning Assets.The sample period is 2012-2015.The sample consist of 46 banks in each year.Statistics of mean and standard deviation are reported.The figures are reported in €millions.

Variables	**2012**		**2013**		**2014**		**2015**	
CEB	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Deposits	102000	164000	201000	241000	183000	237000	192000	254000
Equity	14600	25500	26300	28600	25200	32400	21800	26000
Interest Expenses	2364.670	4079.081	4843.556	4663.578	4468.848	5526.594	5519.338	7268.101
Non-Interest Expenses	3439.542	5184.077	8510.531	11200	8020.842	11100	8040.886	11200
Non-Interest Income	1774.127	2507.695	4805.569	7210.758	5196.193	7502.364	4758.644	7543.122
Other Earning Assets	126000	215000	458000	768000	482000	819000	544000	969000
Loans	119000	214000	94300	179000	95300	179000	92100	169000

Non-CEB and CEB, the inputs and outputs are constantly increasing and decreasing over the years. The inputs such as deposits and equity are larger for the CEB. However, costs for both CEB and Non- CEB declined in the following year of the capital exercise. Before it started to rise again. The outputs for non-CEB have been lesser than CEB in the following years. The capital exercise reduced the inputs and outputs for CEB when compared with the Non-CEB.

Table 2.15 shows the descriptive statistics for the bank characteristics for Non-CEB. Initially, LOGTA was increasing. After the capital exercise, LOGTA has decreased and is lesser than the initial position. EQASS which is a measure of the capital strength has increased over the years. LOANTA and NPL had been increasing until the capital exercise took place. After the capital exercise, it has been declining. On average, ROE has been increasing and decreasing over the years.

Table 2.16 shows the descriptive statistics for the bank characteristics for CEB. Over the years, the average LOGTA and EQASS have remained almost the same. After the capital exercise, the other bank characteristics variables such as LOANTA, NPL, and ROE have witnessed either an increase or a decrease. On average, LOANTA has decreased from 2008 till 2011. In 2012, it increased for a couple of years before starting to decrease again. In 2015, LOANTA is lesser than it was before the capital exercise. NPL was lower on average before the capital exercise took place. However, after the capital

Table 2.15: Descriptive Statistics for Bank Characteristics variables for Non-CEB.Bank Characteristics variables are :-Size,Capital Strength,Loan Activity,Asset Quality and Profitability.The sample period is 2008-2015.The sample consists of 148 banks in 15 EU countries.Statistics of mean,standard deviation, minimum and maximum are reported.

Variable	NON-CEB	LOGTA	EQASS	LOANTA	NPL	ROE
2008	Mean	16.16	0.083	0.633	6.897	3.957
	Std. Dev.	2.810	0.045	0.218	7.307	6.407
	Min	10.28	0.014	0.051	0.825	-11.63
	Max	21.52	0.226	0.869	28.86	18.86
2009	Mean	16.26	0.087	0.635	7.356	4.185
	Std. Dev.	2.807	0.040	0.198	6.810	8.424
	Min	10.51	0.024	0.080	0.992	-21.71
	Max	21.45	0.182	0.857	26.29	22.94
2010	Mean	16.21	0.084	0.640	8.050	5.169
	Std. Dev.	2.732	0.037	0.185	9.904	7.432
	Min	10.71	0.025	0.047	0.952	-18.15
	Max	21.49	0.176	0.881	37.81	29.03
2011	Mean	16.10	0.079	0.636	8.213	-3.883
	Std. Dev.	2.791	0.038	0.177	9.636	40.72
	Min	10.83	-0.002	0.190	1.016	-231.4
	Max	21.53	0.180	0.889	34.52	19.89
2012	Mean	15.76	0.085	0.618	7.297	6.139
	Std. Dev.	2.840	0.049	0.193	8.033	33.23
	Min	10.43	-0.019	0.101	0.831	-40.84
	Max	21.58	0.272	0.878	37.81	185.7
2013	Mean	15.75	0.086	0.624	5.604	-2.797
	Std. Dev.	2.735	0.042	0.196	5.971	34.96
	Min	10.47	0.034	0.093	0.955	-162.2
	Max	21.58	0.227	0.875	32.44	31.03
2014	Mean	15.78	0.092	0.620	6.876	3.334
	Std. Dev.	2.710	0.045	0.199	6.382	12.55
	Min	10.51	0.037	0.094	1.221	-58.58
	Max	21.56	0.228	0.862	34.52	35.23
2015	Mean	15.73	0.097	0.606	7.113	3.687
	Std. Dev.	2.711	0.049	0.207	6.120	9.956
	Min	10.90	0.037	0.036	0.821	-36.88
	Max	21.47	0.266	0.871	28.84	27.71

exercise, NPL reached its highest value. Since then, it has been constantly decreasing. ROE has been constantly varying over the years. It is increasing for a few years and it starts decreasing.

On average LOGTA for CEB has been greater than Non-CEB over the years. EQASS for Non-CEB has been greater than CEB over the years.

Table 2.16: Descriptive Statistics for Bank Characteristics variables for CEB.Bank Characteristics variables are :-Size,Capital Strength,Loan Activity,Asset Quality and Profitability.The sample period is 2008-2015.The sample consists of 46 banks in 15 EU countries.Statistics of mean,standard deviation, minimum and maximum are reported.

Variable	CEB	LOGTA	EQASS	LOANTA	NPL	ROE
2008	Mean	16.85	0.007	0.680	3.526	14.75
	Std. Dev.	3.343	0.117	0.053	2.203	15.49
	Min	12.06	-0.198	0.620	1.882	3.581
	Max	20.76	0.094	0.737	6.036	41.15
2009	Mean	16.87	-0.004	0.695	3.441	7.568
	Std. Dev.	3.213	0.148	0.037	2.825	4.559
	Min	12.33	-0.268	0.638	0.831	3.368
	Max	20.64	0.092	0.739	6.448	12.92
2010	Mean	16.89	-0.012	0.626	3.453	6.114
	Std. Dev.	3.179	0.165	0.115	2.825	4.561
	Min	12.45	-0.305	0.453	1.427	1.121
	Max	20.65	0.088	0.737	6.686	12.61
2011	Mean	16.84	0.027	0.678	10.23	2.612
	Std. Dev.	3.214	0.077	0.058	4.440	10.34
	Min	12.54	-0.102	0.619	7.091	-14.44
	Max	20.64	0.092	0.756	13.37	13.34
2012	Mean	16.43	0.086	0.667	14.26	6.602
	Std. Dev.	2.947	0.026	0.087	17.18	7.469
	Min	13.42	0.043	0.579	2.115	-1.578
	Max	20.64	0.118	0.816	26.41	14.13
2013	Mean	15.99	0.077	0.663	17.07	1.355
	Std. Dev.	2.944	0.028	0.086	20.40	11.32
	Min	13.06	0.044	0.544	2.641	-22.24
	Max	20.53	0.119	0.789	31.54	13.17
2014	Mean	16.07	0.078	0.627	11.10	5.074
	Std. Dev.	2.915	0.029	0.093	15.11	4.556
	Min	13.41	0.045	0.522	1.526	0.314
	Max	20.55	0.118	0.804	28.53	12.72
2015	Mean	16.13	0.078	0.647	9.407	4.902
	Std. Dev.	2.857	0.030	0.118	11.29	4.454
	Min	13.37	0.047	0.453	2.423	-0.073
	Max	20.57	0.125	0.760	26.29	12.72

EQASS for CEB was decreasing at a greater rate before the capital exercise took place. However, after the capital exercise took place. EQASS has increased for both CEB and Non- CEB. In 2012, EQASS for CEB was greater than Non- CEB. But, in the following years, it was overtaken by Non-CEB. LOANTA has been greater for CEB in comparison to the Non-CEB. After the

capital exercise, it has been declining for both. Additionally, after the capital exercise, NPL has been decreasing for the CEB while it is increasing for the Non-CEB. For both CEB and Non-CEB, ROE has been increasing and decreasing over the years.

2.6.2 Boostrap DEA - Bank level analysis

Table 2.17: Average Technical Efficiency before and after Capital Exercise for CEB and Non-CEB.Bootstrap DEA is used for calculating efficiency scores.The sample period for before the Capital Exercise is 2008-2011.The sample period for after the Capital Exercise is 2012-2015.CEB consists for 46 banks for each year.Non-CEB consists of 148 banks for each year.Reported is the Efficiency score in the sample period in sample group.

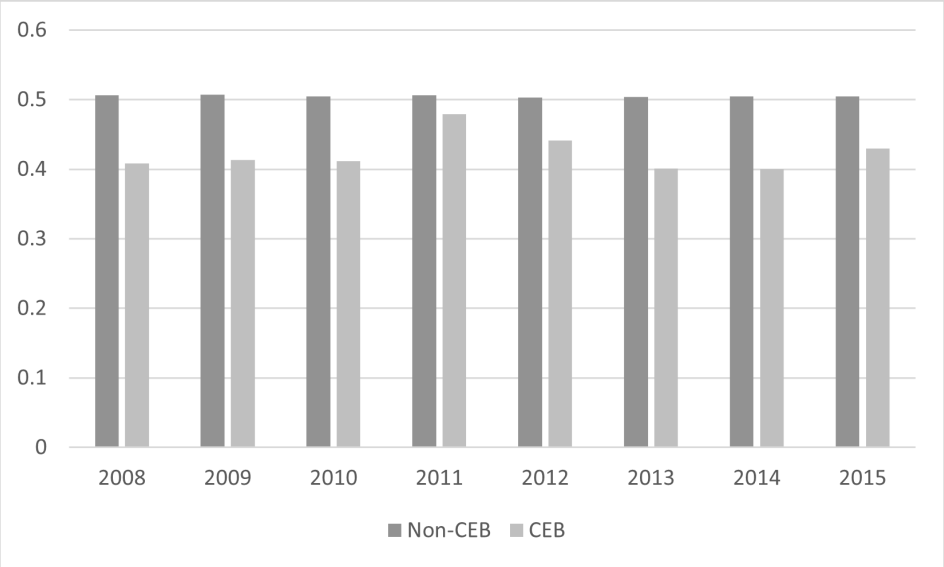
	Before Capital Exercise	**After Capital Exercise**
Non-CEB	0.502	0.479
CEB	0.367	0.375

Table 2.17 presents the results of the Bootstrap DEA for both Non-CEB and CEB. The average efficiency score of the non-CEB before the capital exercise was .502 and after the capital exercise is .479. Before the exercise, the average non-CEB could improve its technical efficiency by 49.8%. But, after the exercise, it would be improving by 52.1%. In other words, if the average bank was producing on the frontier instead of its current location, only 50.2% of the inputs currently being used would be necessary to produce the same output vector, However, after the exercise, only 47.9% of the inputs currently being used would be necessary to produce the same output vector.

For CEB, before capital exercise, it was .367 and after the exercise, it is .375. Before the exercise, the average CEB could improve its technical efficiency by 63.3%. But, after the exercise, it would be improving by 62.5%. In other words, if the average bank was producing on the frontier instead of its current location, only 36.7% of the inputs currently being used would be necessary to produce the same output vector, However, after the exercise, only 37.5% of the inputs currently being used would be necessary to produce the same output vector.

After the capital exercise took place, for the non- CEB banks, there is a 2.3% drop in the average technical efficiency. However, the CEB banks have an increase of about 1% in the average technical efficiency. This could be

Figure 2.2: Efficiency of the banks over time for CEB and Non-CEB.Bootstrap DEA is used for calculating the efficiency scores.CEB consists for 46 banks for each year.Non-CEB consists of 148 banks for each year.Reported is the average Efficiency score in the sample period in the sample group.



explained by the changes in the inputs and the outputs before and after the capital exercise for both Non- CEB, and CEB. For the Non-CEB, the inputs such as deposit and costs decrease while equity increases. But, the outputs decrease as well. However, for the CEB, all the inputs decrease. But, the outputs such as non-interest income and other earning assets decline. Only, the loan as an output increase. This explains that the CEB has been able to use their resources better than the Non-CEB.

Figure 2.2 shows the average efficiency of the capital exercise banks and the non-capital exercise banks. Over the years, the average efficiency of the capital exercise banks has been lower than the non-capital exercise banks. After the Capital Exercise, the capital exercise banks had a drop in their efficiency from 2011 to 2014. This has been because of the impact of the capital exercise as these banks had to adjust their balance sheets according to the new capital requirements. Before the capital exercise took place, the capital exercise bank from 2008 to 2011 witnessed an increase in the average efficiency. This is because they were able to use their inputs such as deposits, costs, and equity much better to get the outputs non-interest income, loans, and other earning assets. The deposits and equity increase and costs fell. The outputs' non-interest income, other earning assets, and loans increased as well. But, after the exercise took place, the efficiency of the capital exercise banks dropped.

These banks had to readjust their balance sheet. The costs were increased and loans decreased. These banks were not able to utilise their inputs much efficiently to produce the outputs much quickly.

The Global financial crisis hit Europe in 2008. The GDP growth of the Euro area was falling till mid-2009 before it started rising. The effect of the rise in GDP growth could be seen in the mean efficiency of the CEB. During the crisis, the largest banks were hit the worst. As a result, it is more noticeable to see the impact on their mean efficiency. The efficiency of the CEB does not increase despite the increase in GDP growth. This is because of the Eurozone Debt Crisis hitting Greece, Italy, Portugal, and Spain. Since, the study has CEB from these countries, despite a growth in the GDP. The efficiency of the CEB does not increase. The bailouts and government intervention has helped in improving the efficiency of CEB. In October 2011, the capital exercise has been announced. The efficiency of the CEB witnessed a decline in 2012. This is accompanied by negative GDP growth. In 2013, Ireland has been hit with a crisis. In 2014, Greece started causing panic among the policymakers. This was accompanied by inflation falling to record lows in the Eurozone and the collapse of the oil price. The efficiency of the CEB suffers s because of these events. The banks started adjusting to the drop in oil prices. The investors welcomed the announcement of Quantitative Easing by the European Central Bank. Furthermore, the EU was able to address the issue of deflation. These contributed to improving the efficiency of the CEB. However, for Non-CEB, uncertainty regarding the Brexit and terms of a bailout for Greece has contributed to a slight decline in the efficiency. Moreover, the non-CEB was not much efficient in handling the issue of deflation. Moreover, the CEB is still working on maintaining its liquidity after the years of crisis and working to meet the requirements of the EBA.

Table 2.18 shows the trend of the efficiency in the capital exercise banks and non-capital exercise banks pre-treatment and post-treatment. There has been a significant change in the efficiency between the capital exercise bank and non-capital exercise banks. After the capital exercise, the banks to adjust their balance sheets and their business model. The difference between the efficiency between the capital exercise banks and non- capital exercise banks is because of the inputs and the outputs. After 2011, there was a drop in the

Table 2.18: This table presents the mean difference change in the efficiency for the capital exercise banks and non-capital exercise banks pre-treatment and post-treatment.Bootstrap DEA is used for calculating efficiency scores.Pre-treatment period is 2008-2011.Post-treatment period is 2012-2015.CEB consists for 46 banks.Non-CEB consists of 148 banks .The delta is efficiency in difference between Non-CEB and CEB (***statistically significant at 1% level, **statistically significant at 5% level, *statistically significant at 10% level).

Efficiency	**Non-CEB**	**CEB**	**Delta**
2008-2011	-0.034	-0.037	0.003
2009-2011	0.009	0.078	-0.069
2010-2011	0.024	-0.162	0.184*
2011-2012	0.007	-0.118	0.125**
2011-2013	-0.036	0.037	-0.073**
2011-2014	0.029	-0.024	0.053*
2011-2015	0.002	-0.074	0.076

inputs and outputs for the capital exercise which contributed towards the mean difference of the capital exercise banks to be lower than non-capital exercise banks. Furthermore, the other bank characteristics fell for the capital exercise banks. ROE and NPL for the capital exercise bank reduced while capital strength increased for the capital exercise bank.

Table 2.18 allows to make comparison with the mean difference change in the efficiency for capital exercise banks and non-capital exercise banks pre-treatment and post-treatment. The Global financial crisis hit Europe in 2008. This crisis hit the CEB banks in terms of efficiency more than the Non-CEB. The CEB includes the banks with the largest assets. During the crisis, these banks were hit worse than the Non-CEB. The efficiency of the bank started improving in the following years for both CEB and Non-CEB. In 2010, the Sovereign Debt Crisis hits Europe. The CEB suffers badly in terms of efficiency while the Non-CEB doesn't suffer. After the capital exercise took place, there is a change in the efficiency of both CEB and Non-CEB. The mean difference change in efficiency for the Non-CEB has got worse than it was before the capital exercise and for the CEB, there was a slight improvement. However, in the following year, the Non-CEB continues to do worse than the CEB. In 2014, Greece started causing a panic among the policymakers. Moreover, inflation had fallen to record lows. This affected the efficiency of the CEB badly. Furthermore, the EU rebuffed Greece's Demand for Austerity Relief.

This led to the efficiency of the CEB suffering more.

2.6.3 Double Bootstrap Truncated Regression Results – Bank-Level Analysis

Table 2.19: The Double Bootstrap Truncated regression results for the Non-CEB and CEB before the capital exercise took place. The model controls for bank characteristics.CEB consists for 46 banks.Non-CEB consists of 148 banks.The period is 2008-2011. QML (Huber/White) standard errors and covariates have been calculated to control for heteroscedacity (***statistically significant at 1% level, **statistically significant at 5% level, *statistically significant at 10% level).

VARIABLES	**Non-CEB**	**CEB**
LOGTA	-0.003	-0.058
	(0.049)	(0.045)
EQASS	-0.309	-12.34
	(0.439)	(5.490)**
LOANTA	-0.024	-3.892
	(0.065)	(1.865)*
NPL	-0.002	-0.074
	(0.001)*	(0.021)*
ROE	0.000	-0.025
	(0.000)	(0.009)*
CONSTANT	0.621	5.989
	(0.123)***	(2.534)*
R-square	0.10	0.66
Maximum Likelihood	67.89	40.23
Observations	592	184

Table 2.19 represents the Simar and Wilson (2007)'s Truncated regression results for Non-CEB and CEB banks before the capital exercise took place. R- Square is used as one of the indicators for measuring the goodness of fit for the model. A low R-square shows significant variables and explains little about the variability. It has been found that a low R-square does not mean poor explanatory power. The regression model includes both cross-sectional and time data. If time data is dominant in the panel, R-squared is higher, if the cross-sectional are dominant in the panel R-squared is low. In this model,

cross-sectional data is dominant. The number of banks is 148 and the number of years is 4. Furthermore, this is the time of the period of the financial crisis. The variability in the data is very high during this period. Therefore, the R-square is low. Additionally, R-Square could not determine whether the model is adequate or not. In this study, we conducted the F-test to check the significance of the model. For the table, the model for Non-CEB, the F-test has a p-value of .003. This is less than 5%. This shows the model is a better fit. The model for CEB, the F-test has a p-value of 0.0000. This is less than 5%. This shows that the model is a better fit. Following Pasiouras (2006) and Pasiouras (2008), QML (Huber/White) standard errors and covariates are calculated. This is because heteroskedasticity can emerge when estimated parameters are used as dependent variables in the second stage analysis.

The regression model for both CEB and Non-CEB fits the data well for this study. NPL has a negative significant relationship with the efficiency of both Non- CEB, and CEB. This finding suggests that if the bank is having a higher non-performing loan, it would be problematic for the banks. In the past, it has been witnessed that serious banking problems have arisen from the failure of the banks to recognize impaired assets and create reserves for writing off these assets. For CEB banks, EQASS exhibits a negative relationship with bank efficiency. The findings imply that the more efficient banks, use less equity compared to its peers. The results seem to suggest that the less efficient banks could have been involved in riskier operations and the process tends to hold more equity, voluntarily or involuntarily, i.e., the reason might be banks' deliberate efforts to increase safety cushions and in turn decrease the cost of funds or perhaps regulatory pressures that mandate riskier banks to carry more equity. LOANTA has a significantly negative impact on the technical efficiency of the bank. This is in line with the findings of Havrylchyk (2006) who found a negative relationship between LOANTA and efficiency. This ratio is considered as a proxy for Liquidity risk. Therefore, a negative relationship could indicate that less efficient banks are also less liquid. ROE is having a negatively significant impact on the efficiency of the bank. This finding indicates that the more profitable banks have lower inefficiency. This corroborates with similar findings of the other studies(Pastor et al., 1997; Das and Ghosh, 2006). Banks that are reporting higher profitability ratios are

usually preferred by the clients. Therefore, they attract the biggest share of deposits along with the best potential creditworthy borrowers. Moreover, this implies that the banks might be having a higher ROE by either having higher leverage (debt) or higher risk-taking.

Before Capital Exercise took place, EQASS, NPL, and LOANTA are negatively economic significant on the efficiency for Non-CEB. For CEB, the efficiency could be improved by 1% if NPL is reduced by 0.130%. However, it is not economically significant. The results indicate that banks were not involved in careful lending. As careful lending would impacting on the better performance of the bank. The efficiency of the banks could have been improved by getting involved in less risky activities. The results show that the banks have got involved in riskier activities. Furthermore, the results indicate the need for the banks to be focusing on credit risk management, which has been a problematic issue in the past (Kwan et al., 1995; Resti, 1997). The capital regulations have a significant role to play towards the incentives of the banks with depositors and other creditors. Additionally, capital regulation would be contributing to having less non-performing loans. These results reflect the significance of the need for the introduction of capital exercise.

Table 2.20 represents the regression results after the capital exercise took place. In this study, the F-test has been used to check the significance of the model. For the table, the model for Non-CEB, the F-test has a p-value of 0.00000. This is less than 5%. This shows the model is a better fit. The model for CEB, the F-test has a p-value of 0.0000. This is less than 5%. This shows that the model is a better fit. The regression model for both CEB and Non-CEB fits the data well for this study. After the capital exercise, LOGTA exhibits a significant positive relationship with the technical efficiency of the bank for CEB. This finding is in line with the findings of Chortareas et al. (2011). As the size of the bank grows, the bank would be able to have a bigger portfolio and loan diversification and gain from size advantages. The large banks would be able more efficient because of the economies of scale. This would be because two reasons explained by Hauner (2005). Firstly, if it relates to market power, large banks should pay less for their inputs. Second, there may be increasing returns to scale through the allocation of fixed costs over a higher volume of services or from efficiency gains from a specialised workforce.

Table 2.20: The Truncated regression results for the Non-CEB and CEB after the capital exercise took place.CEB consists for 46 banks.Non-CEB consists of 148 banks.The period is 2012-2015.QML (Huber/White) standard errors and covariates have been calculated to control for heteroscedacity .(***Statistically significant at 1% level, **Statistically significant at 5% level , *Statistically significant at 10% level).

VARIABLES	**Non-CEB**	**CEB**
LOGTA	0.001	0.160
	(0.004)	(6.987)**
EQASS	-0.094	-16.89
	(0.318)	(6.321)**
LOANTA	-0.562	0.245
	(0.081)***	(3.689)**
NPL	-0.003	-0.007
	(0.001)**	(5.671)**
ROE	-0.001	0.058
	(0.000)**	(5.743)**
CONSTANT	0.878	4.561
	(0.110)***	(6.985)**
R-square	0.320	0.634
Log Likelihood	98.10	61.32
Observations	592	184

LOANTA has a positive relationship with efficiency for CEB while it has a negative relationship for Non-CEB. The findings imply that the CEB with higher loans to asset ratios tend to have higher efficiency scores. The EBA looks to have made the CEB value loans more highly valued than alternative bank outputs, i.e. Investments and securities. For non-CEB, the EBA looks to be trying to make the non-CEB banks be more liquid and trying to be careful in their lending practices. NPL and ROE have a significant negative relationship on the technical efficiency for both CEB and Non-CEB. EQASS exhibits a negative relationship with technical efficiency only for the CEB.

After capital exercise, EQASS and NPL are negatively economic significant on the efficiency of Non-CEB. For CEB, the efficiency could be improved by 1% if NPL is reduced by 1.23%. This shows NPL is economically significant. LOANTA is positively economic significant on the efficiency of the banks for CEB. While ROE is negatively significant on the efficiency of the CEB. The

results show that capital exercise is influencing the quantity and quality of lending made by the banks and the decision of the banks when allocating their asset portfolios. The balance sheet of the bank is getting more inclined towards liquidity than lower returns portfolios. The capital requirement would be creating an incentive for the banks to have fewer non-performing loans. The results are consistent with the findings of Kwan et al. (1995) and Resti (1997)). Additionally, the results show that the capital exercise has contributed towards the banks' incentives of the banks with depositors and other creditors (Barth et al., 2013b). Furthermore, the results show that capital exercise has been aimed at reducing higher risk-taking and leverage (debt). The results imply that the higher capital requirements have contributed to preventing the banks from getting involved in higher risk-taking. Moreover, the capital requirements by the EBA would be reducing the likelihood of financial distress.

The bank characteristics have a significant impact on the technical efficiency of the banks.The EBA capital announcement has made the banks consider their activity in the banking sector and to manage their portfolios. As a result, the banks would be having less likelihood of having financial distress. The EBA has looked to prevent the banks from potential systemic risk. The EBA's capital announcement has contributed towards the banks getting involved in careful lending practices which would be improving the overall performance and soundness of the banks. Furthermore, The EBA announcement has contributed towards the bank getting engaged in more profitable activities. As a result, they would be able to attract the best potential creditworthy borrowers who would be able to meet the obligations. This could be resulting in banks having less loan loss. Moreover, these conditions would be creating an environment for the banks to become more profitable and efficient.

2.7 Conclusion

This study employs Bootstrap data envelopment analysis and Simar and Wilson (2007) Truncated regression to examine the impact of the EBA's capital exercise on the bank's technical efficiency. The sample consists of 194 commercials banks operating in 15 European countries from 2008-2015.The results of the Bootstrap DEA indicate that the average bank in the sample could

improve its technical efficiency by 49.4%. But, before the announcement, it was 47.53%. The results indicate that the capital exercise has contributed to a slight increase in the average bank in the sample for improving its technical efficiency.

Following the Bootstrap DEA results, Simar and Wilson (2007)'s Bootstrap Truncated model is used while controlling for the bank-specific characteristics and country-level characteristics accounting for macroeconomic conditions, financial development, and market structure. The capital exercise announcement has led to a change in the bank-specific characteristics which determine the technical efficiency of the bank. The study found that profitability has a significant effect on the efficiency of the bank. Banks that are reporting higher profitability ratios are usually preferred by the clients. Therefore, they attract the biggest share of deposits along with the best potential creditworthy borrowers. Capital has a significant positive impact on efficiency. By having a higher capital, the EBA has aimed in improving the confidence of depositors in the bank's security. Additionally, it would be creating an environment for careful lending and better bank performances.

While controlling for the macroeconomic conditions, real GDP growth has a positive significant impact on the technical efficiency of the bank. As the economy grows, the debtors would be able to meet their obligations. Also, the capital, Non-performing loans, ROE, and Loan Activity have a significant impact on technical efficiency. The banks would be required to hold more capital than before and have a higher regulatory screening than before.

When controlling for financial development, the activity in the banking sector and banking market size have a significant and positive relationship with the efficiency. While Loan Activity and ROE has a negative impact. This indicates that the activity in the banking sector and its size are significant for efficiency. The EBA capital announcement has made the banks consider their activity in the banking sector and to manage their portfolios. As a result, the banks would be having less likelihood of having financial distress.

While controlling for the market structure, LOANTA, ROE, and NPL has a negatively significant impact on the efficiency of the bank. The EBA's capital announcement has aimed to make the banking market less concentrated. This would be contributing to having banks less prone to potential systemic risk.

Furthermore, it would be improving the overall performance of the banks and the soundness of the banks.

Finally, when controlling for all the factors, GDP growth, activity in the market, and the market size are affecting the efficiency of the bank positively. However, LOANTA and CONC have a significantly negative impact on the efficiency of the bank. The results indicate that the stability of the banks would improve and the banks would be under less distress. It would be making them sounder.

For the bank-level analysis, the average efficiency of the capital exercise banks has been lower than the non-capital exercise banks. After the Capital Exercise, the capital exercise banks had a drop in their efficiency from 2011 to 2014. This has been because of the impact of the capital exercise as these banks had to adjust their balance sheets according to the new capital requirements. After the capital exercise, LOGTA exhibits a significant positive relationship with the technical efficiency of the bank for CEB. LOANTA has a positive relationship with efficiency for CEB while it has a negative relationship for Non-CEB. NPL and ROE have a significant negative relationship with the technical efficiency for both CEB and Non-CEB. EQASS exhibits a negative relationship with technical efficiency only for the CEB.

The stricter capital regulations by the EBA would only be improving the efficiency of the banks if the regulatory screening ability is low. When the capital regulations are placed, the banks are looking to substitute the loans with alternative forms of assets. The banks are looking for different asset portfolios which would be generating better returns and requires the different resources to be managed. The results indicate that the capital requirement by the EBA which came as a shock for the banks would be contributing towards making the banks more stable. It would be preventing banks from excessive risk-taking activities. Furthermore, it would be allowing the banks to withstand financial distress. Although, the capital requirements would not be a highly significant benefit for the efficiency gains. But, it would be creating favourable economic conditions which would affect the extent, depth, and quality of financial intermediation and banking services.

Chapter 3

An analysis of Risk measures on the Cost Efficiency of the Banks.

3.1 Introduction

The financial crisis revealed the problems in the banking sector for supervisors and other stakeholders in identifying and comparing the bank's information across different jurisdictions.The Basel Committee found that there are no consistent international standards for categorising problem loans.Banks used different methodologies and assumptions for valuations, provisioning and risk weightings, increasing opacity, and reducing comparability for end-users (BIS, 2016).At the height of the crisis, this inconsistency increased the uncertainty in the banking sector.Furthermore,it frustrated supervisors and investors who tried to compare and assess the bank's performance and risk.As a result,the regulators,supervisors,and macroprudential authorities have made joint efforts for addressing the issue of having enhanced comparability of this terminology.This would result in increased harmonisation of practice enabling supervisors and market participants to have a better understanding of the asset quality issues.

The definition of Non-Performing Exposures (NPEs) introduces harmonised criteria for categorising loans and debt securities that are centred on delinquency status (90 days past due) or the unlikeliness of repayment (BIS, 2016).It clarifies the consideration of collateral in categorising assets as non-performing. This new definition will provide an internationally consistent reference point for supervisors and banks' management in identifying levels of NPEs in ab-

solute and relative terms and facilitate timely action to address rising asset quality problems.NPEs ratio is defined as the sum of outstanding nonperforming loans, advances, and debt securities divided by all gross carrying amounts of loans, advances, and debt securities.NPEs is the widest concept as it includes loans, debt securities, and certain off-balance sheet exposures,but may exclude certain asset classes, such as foreclosed collateral.

NPEs are considered to be a problem at multiple levels: at the microprudential level, high levels of NPEs are associated with lower profitability and lower efficiency; at the macroprudential level, high levels of NPEs are connected with stagnant growth, as capital is tied up in NPEs and there is decreased new lending into the real economy (EBA, 2017).The high levels of NPEs negatively affect the resilience of the banking sector to shocks and hence increase systemic risk.For consumers, an inability to meet the obligations of the credit contract could have a detrimental impact on their financial situation and social circumstances.All of these effects must be tackled comprehensively.As a result, policymakers have increasingly focused on NPEs and aimed at developing a plan to foster new solutions and tools for addressing this issue.

In the recent crisis, liquidity crunches became too apparent.As a result, bank liquidity has become an important focus of the financial regulatory reforms.Liquidity risk has been recognised as a significant threat to financial institutions' management and financial system stability.Generally, banks are required to maintain a liquidity buffer for managing liquidity risk and to insure against liquidity shocks.Hong et al. (2014) showed that systematic liquidity risk was an important contributor to bank failures occurring over 2009–2010 in the aftermath of the crisis. Furthermore, they found that liquidity risk could lead to bank failures through systematic and idiosyncratic channels. The theoretical predictions of Acharya and Naqvi (2012) and Wagner (2007) on the implications of short-term liquidity for bank risk-taking and bank stability suggest that the high levels of asset liquidity could potentially increase bank risk. Also, it requires further attention because of the significant welfare costs which risky banks may pose as witnessed in the recent crisis. Deposits shields the banks from bank run risk. Banks with higher deposits have less funding liquidity risk which reduces market discipline and leads to higher risk-taking by banks.Keeley (1990) found that deposit insurance creates a moral hazard

for excessive risk-taking by banks in response to increase in deposits at the cost of the deposit insurer.Drehmann and Nikolaou (2013) defined funding liquidity risk as to the banks' failure to settle obligations immediately and measure funding liquidity risk based on banks' aggressive bidding at central bank auctions to secure liquidity. Following Khan et al. (2017), this study considers that banks with higher deposits have lower funding liquidity risk because these banks will have an adequate amount of funds to settle their obligations. Furthermore, there is a lesser probability of a bank run risk in the presence of deposit insurance.

This study attempts to fill in the gap by providing evidence on how the NPEs and Funding Liquidity risk impact on the cost efficiency of the banks. Using data for banks in 6 different global regions from 2010 to 2018, this study investigates the impact of the NPEs and Funding Liquidity Risk on the Cost Efficiency of the banks. NPEs are measured as the sum of outstanding non-performing loans, advances, and debt securities divided by the gross carrying amount of loans, advances, and debt securities. Following Acharya and Naqvi (2012),and Khan et al. (2017),this study consider the amount of deposits relative to total assets as our proxy for banks' funding liquidity risk.This is because deposits protect the banks from run risk. Liquidity Risk is measured as the ratio of liquid assets to total assets. To conduct a comprehensive analysis of the effects of NPEs, Funding Liquidity Risk, and Liquidity Risk on the efficiency of the banks. To analyze the role of NPEs and Funding Liquidity Risk on cost efficiency, the study adopts a heteroscedastic stochastic frontier model in the estimation. This allows us to specify both the mean and variance of the inefficiency instability and investigate the non-monotonic effects on efficiency. This study aims to provide a comprehensive analysis of the effects of NPEs, Funding Liquidity Risk, and Liquidity Risk on the efficiency of the banks. The study uses a sample of 2630 banks from 163 countries, which is comprehensive in terms of geographical coverage. Furthermore, this study looks into the marginal effects of the risk measures on cost efficiency. In addition, the study investigates the marginal effects on risk measures on cost efficiency over time and across different regions.

The study focuses on how risk measures affect the level and variability of the inefficiency effect. The results indicate Funding Liquidity Risk has a

positive effect on the mean and the variance on the inefficiency effect. This means a bank with a higher Funding Liquidity Risk will have a lower and more varied cost efficiency. Liquidity Risk has a significantly positive effect on the inefficiency effect. This indicates that an increase in Liquidity Risk lowers the profitability of the bank, which pushes down the cost efficiency of the bank and increases the fluctuation of the cost efficiency. Additionally, NPEs have a significantly positive effect on the mean and variance of the inefficiency effect.

The study compares average cost efficiency and marginal effects of the risk measures on the mean and variance across the groups sorted by the criteria variables. The criteria variables are risk measures such as Funding Liquidity Risk, Liquidity Risk, and NPEs. The results indicate that there are non-linear effects of some of the risk factors such as Funding Liquidity Risk and NPEs on the mean and variance of the inefficiency effect. However, for Liquidity Risk, the marginal effects indicate a non-monotonic effect.

The study investigates the effects of the time trends of cost and average marginal effects on mean and variance over the sample period. The effects of the risk measures are not consistent over time. For Funding Liquidity Risk, the marginal effect on the mean is very high in 2011. After 2011, the effect starts declining until 2016. However, from 2017 onwards, the effect has again started increasing. The marginal effect shows the negative effect on cost efficiency. The marginal effect on variance has both a negative and positive effect on cost efficiency over the years. For Non-Performing Exposures, The marginal effect on mean has a positive effect on the cost efficiency and the marginal effect on variance shows inverse U-shape like pattern. For Liquidity Risk, the marginal effect on mean shows U-shape pattern and on variance has a negative effect on the cost efficiency.

The study compares the trend pattern of each region's cost efficiency. The Cost Efficiency of Africa and Latin America and Caribbean have been lower than in other regions over time. The average cost efficiency in the United States and Canada has been declining since 2011. Over the years, the cost efficiency in the Middle East has deteriorated. Global cost Efficiency has been decreasing until 2018. The events across the different regions have contributed to this decline in efficiency. However, in 2018, the global cost efficiency has increased along with most of the regions witnessing an increase in efficiency.

To test the endogeneity problem, this study adopts a Durbin-Wu-Hausman test. Funding Liquidity Risk, Liquidity Risk, and Non-Performing Exposures are treated as endogenous. The identification requires at least three instrumental variables, the study selects Deposits, Wholesale Funding, and Non-Performing Assets. The result of Durbin–Wu–Hausman test does not indicate that the endogeneity problem is a concern in this study.

The rest of the study is structured as follows. Section 3.2 provides an overview of Non-Performing Exposures, determinants of Non-performing loans, and a review of studies of bank efficiency using Non-performing loans. Section 3.3 provides an overview of Funding Liquidity Risk. Section 3.4 outlines a review of cost efficiency, a review of studies that investigate risk and bank efficiency, and a review of studies which analysed Cost Efficiency using Stochastic Frontier Analysis. Section 3.5 presents the sampling methodology used in this study. Section 3.6 discusses the results and Section 3.7 concludes the study.

3.2 Non-Performing Exposures

3.2.1 Background

The global financial crisis revealed difficulties for supervisors and other stakeholders in identifying and comparing the bank's information across different jurisdictions. Banks used different methodologies and assumptions for valuations, provisioning, and risk weightings(BIS, 2016). This increased opacity and reduced comparability for the end-users. At the height of the crisis, this inconsistency increased which frustrated supervisors and investors who tried to compare and assess banks' performance and risk(BIS, 2015). This impeded the assessment of risks and implementation of solving strategies by the regulators. Furthermore, it contributed to creating concerns in markets about the asset quality in the banks.

The overall level remains high by historic standards, even though the joint efforts of banks, supervisors, and macro-prudential authorities have led to a slow improvement in NPEs ratios over recent years. Among EU member states, the stock of NPEs is spread unevenly (EBA, 2017). European Banking Authority (EBA) found that the member states experienced above-average NPE ratios (EBA, 2017). The effects of high levels of NPEs in bank balance sheets

on funding costs and capital and efficiency among others can seriously jeopardise institutions' ability to run a viable and sustainable business model. NPEs are a problem at multiple levels: at micro-prudential level, high levels of NPEs are associated with lower profitability and lower efficiency; at macro-prudential level, high levels of NPEs are connected with stagnant growth, as capital is tied up in NPEs and there is decreased new lending into the real economy (EBA, 2017). In addition, high stocks of NPEs negatively affect the resilience of the banking sector to shocks and hence increase systemic risk. Finally, for consumers, an inability to meet the obligations of the credit contract could have a detrimental impact on their financial situation and social circumstances(EBA, 2018). All of these effects must be tackled in a comprehensive manner.

3.2.2 Definition

In particular, the Basel Committee on Banking Supervision recognised that there might be significant differences in how banks identify and report their asset quality (BIS, 2015). There were no consistent international standards for categorising problem loans. To respond to this issue, the Basel Committee issued guidelines for non-performing exposures. The definition is built on the commonalities in the existing definitions of many countries. This would help to harmonise the quantitative and qualitative criteria used for credit categorisation and provide the starting point for countries with no existing definitions to develop them(BIS, 2015). Furthermore, the definition is designed for supervisory purposes and is not intended to undermine accounting standards, which drives the accuracy of loan impairments and associated s in published financial statements (BIS, 2016).

The definition of non-performing exposures introduces harmonised criteria for categorising loans and debt securities that are centred on delinquency status (90 days past due) or the unlikeliness of repayment (BIS, 2016). It also clarifies the consideration of collateral in categorising assets as non-performing. The definition focuses on a debtor basis but allows the categorisation of exposures as non-performing on a transaction basis for retail exposures (BIS, 2016). It introduces clear rules regarding the upgrading of a non-performing exposure to performing and the interaction between forbearance and non-performing status. According to the Basel Committee, NPEs should always be categorised

for the whole exposure, including when non-performance relates to only a part of the exposure, for instance, unpaid interest (BIS, 2016).

The use of this new definition would allow drawing the same line for all the institutions between performing and non-performing exposures. Also, it would compare asset quality homogeneously and comparably across the banks in different jurisdictions (BIS, 2016). This new definition would be to provide a key foundation for those countries currently without definition NPEs. By disclosing the information, it would play a significant role in influencing market discipline through transparency. NPEs might be used reference points for regulatory and accounting concepts for promoting comparability for risk-weighting, provisioning, and credit loss recognition (BIS, 2016). It will improve discussions about risks and risks tackling strategies in colleges because risk assets will be identified similarly. It will improve the starting point data of the stress tests.

In practice, Non-performing loans (NPLs) is used as a synonym for NPEs. The EBA's definition of NPLs includes nonperforming loans and advances, while NPEs include debt securities in addition to loans and advances. The term non-performing assets are frequently used to also include foreclosed assets. Moreover, off-balance-sheet items are not included in either the NPL ratio or the NPE ratio. The NPL ratio is defined as the sum of nonperforming loans and advances divided by total gross loans and advances. The NPE ratio is defined as the sum of outstanding nonperforming loans, advances, and debt securities divided by all gross carrying amounts of loans, advances, and debt securities. NPEs is the widest concept as it includes loans, debt securities, and certain off-balance sheet exposures, but may exclude certain asset classes, such as foreclosed collateral.

3.2.3 Determinants of Non-Performing Loans

Non-Performing Loans (NPLs) are significant because they reflect the credit quality of the loan portfolio of the banks. In aggregate terms, NPLs reflect the credit quality of the loan portfolio of the banking sector in a country. Prior to the Global Financial Crisis, NPLs were relatively low. However, during and after the crisis, NPLs increased significantly. This has ignited an interest in understanding the determinants of NPLs in different regions of the world.

The studies have ranged from cross-country analysis to country-specific case studies. The empirical literature on the determinants of NPLs is based on the theoretical model, which deals with the business cycle with an explicit role for financial intermediation.

The problems in the banks do not arise from the liability side, but a prolonged deterioration in asset quality. This may be from a collapse in real estate prices or increased bankruptcies in the non-financial sector. In such instances, a large increase in NPLs would better mark the onset of the crisis. However, the indicators of NPLs are available only sporadically and made less informative by bank's desire to hide their problems for as long as possible.Reinhart and Rogoff (2010) showed that often banking crises either precede or coincide with a sovereign debt crisis. Additionally, they found that banking crises are importantly preceded by rapidly rising private indebtedness.

Macroeconomic Conditions

Nkusu (2011) investigated NPL determinants across 26 developed countries from 1998 to 2009 period and found that deteriorating macroeconomic conditions such as economic growth and higher unemployment contributed towards higher NPLs. Further, her results confirmed that adverse macroeconomic developments especially a contraction of real GDP, a higher unemployment rate, and higher interest rates are associated with higher levels of NPL. Interest rates increase can weaken the repayment capacity of the borrower, especially in the case of a variable contract. Increased debt burden caused by increased interest rates would lead to higher NPLs. Klein (2013) investigated 16 Central, Eastern, and South-Eastern Europe (CESEE) countries over 1998 to 2011 period and found that aggregate NPLs are negatively associated with credit growth, unemployment, gross domestic product growth rate, and inflation. Higher inflation can make debt servicing easier by reducing the real value of the loans. However, it can also reduce the income real income of the borrower when wages are sticky. Louzis et al. (2012) investigated NPL determinants in the Greek banking sector and found that NPLs are significantly influenced by management quality, GDP, unemployment, interest rates, and public debt. According to the bad management concept, low cost efficiency is considered as a signal of poor management practices. As a result of poor loan underwriting,

monitoring, and control, NPLs are likely to increase.Škarica (2014) investigated the NPL determinants for seven countries in the Central and Eastern European (CEE) region during the third-quarters of 2007 and 2012. She found that economic slowdown, inflation, and unemployment rate are positively associated with NPLs. The convergence of adverse responses in GDP growth and unemployment leads to a vicious spiral in which the banking system problems and fall in the economic activity reinforce each other.

Jakubík et al. (2013) investigated the determinants of NPLS in 9 CESSE countries. Using GMM estimations with quarterly data from 2004 to 2012, they found that real GDP growth and national stock price index are negatively associated with NPLs. Further, they found that a nation's exchange rate, private credit-to-GDP and past NPLs contributed towards an increase in the current period's NPLs.Beck et al. (2015) investigate the macroeconomic determinants of NPLs across 91 countries and found that NPLs are significantly affected by real GDP growth, share prices, exchange rate, and lending interest rate. In normal times, local currency depreciation has a positive income effect through an increase in net exports. Therefore, it affects the repayment capacity of the borrowers in an open economy. Currency depreciation can cause unfavourable effects, in a case; there is a large share of foreign currency in loans in total loans. The currency depreciation increases the debt servicing costs for the borrowers who have loans denominated in the foreign currency. This is because the incomes of the borrowers are in the local currency and they face more difficulties in paying back their debts.

Dimitrios et al. (2016) focus on the euro-area banking system during the 1990 to 2015 period and found that income tax and output gap significantly influence NPLs. If a borrower has to pay a higher income tax, his disposable income will reduce. The output gap has been theorised to incorporate the potential growth of an economy. As a result, an increase in the output gap would affect NPLs negatively.Messai and Jouini (2013) investigated the determinants of NPLs in Italy, Greece, and Spain for 2004-2008. They found that economic growth and bank profitability contributed to the reduction of NPLs while unemployment rates, real interest rates, and poor credit quality are positively associated with NPLs. Credit quality reflects the overall attitude of the banking system to control risks. With poor credit quality, banks have more

moral hazard incentives by increasing the riskiness of their loan portfolio. This results in higher NPLS. When a bank increases its real interest rates, immediately, it leads to an increase in NPLs especially for loans with floating rates. This is because of the impact on the ability of the borrowers to meet their obligations.Salas and Saurina (2002) investigated the determinants of NPLs in Spanish Commercial and saving banks. They found loans are more sensitive to the business cycle in commercial banks than in saving banks. The different determinants of commercial banks and saving bank NPLs can be explained by the historical differences between customers of commercial banks and saving bank and geographical presence of the bank.

Capital

Regarding bank-specific NPL determinants, (Klein, 2013) found that capital adequacy measured as the equity-to-asset ratio is negatively correlated with NPLs, implying that banks with relatively low capital have incentives to engage in risky lending behaviour which increases the incidence of NPLs. The banks with relatively low capital respond to moral hard incentives by increasing the riskiness of their portfolio. This results in higher NPLs. On the other hand,Boudriga et al. (2009)investigate the cross-country determinants of NPLs while controlling for the impact of banking supervision and institutional factors on credit risk exposure. They show that banking sectors with higher capital adequacy ratios and prudent loan loss provisioning report fewer NPLs. They showed that countries' higher NPLs exhibit lower levels of loan loss provisions. This may reflect the attitude toward risk in the banking industry in the country. Ozili and Thankom (2018) show that European systemic banks, on average, have fewer NPLs than non-systemic banks because systemic banks have superior credit risk management systems to mitigate NPLs compared to non-systemic banks. They also find a negative relationship between bank provisioning and NPLs for both systemic and non-systemic banks in Europe. Additionally, Klein (2013) shows that profitable banks have fewer NPLs because lower NPLs lead to higher interest income which subsequently improves overall Financial development profitability. Ozili and Outa (2018)investigates the determinants of banking stability, using NPLs as a stability indicator. Using data for 48 African countries, Ozili (2018) found that bank efficiency, bank

concentration, foreign bank presence, unemployment rate and the size of the banking sector are significant predictors of aggregate NPLs; however, higher government effectiveness, high competition, and strong legal systems reduced the persistence of NPLs in the post-financial crisis period. Efficient banks tend to report fewer NPLs compared to inefficient banks. This implies the countries with efficient banking systems have fewer NPLs.

Loans

Foos et al. (2010) investigated the U.S., Canada, Japan, and European banks during 1997-2007. They showed that loan growth contributes to an increase in loan losses during the next subsequent years. This causes a decline in both interest income and capital ratio. This is because the borrowers do not immediately default after they have received a bank loan. If the new loans are granted at lower rates, the average outstanding loan volumes generate a lower relative interest income. Additionally, an increase in loan losses may force a bank to reduce loan growth in the future. Demirgüç-Kunt (1989),Berger and Udell (1994) and Gorton and Rosen (1995) have further investigated the relationship between loan growth, non-performing loans and the risk-taking of banks.

Bank Risk Behaviour

Saunders et al. (1990) found that shareholder controlled banks are inclined to take greater risks than managerially controlled banks. They find a positive relationship between managerial stock ownership and risk-taking. This is because bank managers may be more risk-averse than bank owners. Demsetz and Strahan (1997) report a positive and nonlinear relationship between market risk measures and managerial shareholdings. They also report that large bank holding companies offset the potential benefits of diversification through adopting more risky loan portfolios and operating with more leverage. Demsetz and Strahan (1997) concluded that large banks are internally more diversified and can reduce idiosyncratic risk. But, they offset these gains by undertaking riskier activities commercial and industrial lending and increased leverage. Zhou (2014) shows that the diversification of the income structure of China's commercial banks has not significantly reduced banks' overall risk.

Diversification of bank income can bring huge profits but it will also bring new business risk. Non-interest income businesses may bring new operational, market, credit, liquidity, and legal risk. When the non-interest income business is wider, the bank's operational risk is higher.

According to the bank's risk preference, Bernanke and Gertler (1986) pointed out that the impaired loans of banks might induce different bank behaviour. Jia (2009) shows that lending by joint-equity banks has been more prudent than lending by state-owned banks in China. This is because the joint-equity banks tend to have higher excess reserves, higher deposit/loan ratios, and lower loan/asset ratios. Prudential banks tend to be more cautious when they face increasing levels of NPLs. As a result, efficient reforms have been carried out by state-owned banks to become more prudent. However, when the NPL ratio is too high, both the shareholders and bank managers have incentives to shift the risk.

Moral hazard is defined as excessive risk-taking when another party is bearing part of the risk and could not be charged easily for or prevented from that risk-taking.Eisdorfer (2008) reported that the financially distressed firms have greater risk-shifting behaviour.Koudstaal and van Wijnbergen (2012) examined the US banks and found that the banks with more troubled loan portfolio had the greater inclination for banks to take risks.Bruche et al. (2011) showed that when the banks are facing the threat of bankruptcy, they tend to roll over the bad loans. This is done in order to increase their chances of recovery. The regulatory attitude is considered significant as well.Boyd and Graham (1998) and Nier and Baumann (2006)) argued that the moral hazard problem becomes more acute when the banks either feel too big to fail due to their big market power or when they expect to be bailed out in case of insolvency. Soedarmono and Tarazi (2016) showed that greater market power in the banking industry could immediately contribute towards higher instability in the banking system in Asia-Pacific countries. This is because the presence of asymmetric information in loan markets worsens entrepreneurial moral hazard to undertake risky projects to offset higher interest rates charged by banks with higher market power. Higher borrower's risk can in turn negatively affect bank stability through the risk-shifting mechanism. Also, Kim et al. (2016) showed that an increase in the market power for the large banks led to an increase in small

bank's financial instability in the Asian economies. These studies point out that the level of NPLs can be an important determinant of bank behaviour, which can cause them to act differently when facing a higher level of NPLs.

3.2.4 Bank Efficiency using Non-Performing Loans

Banks' asset quality is considered a significant determinant for bank stability and efficiency. Numerous researchers have opened about the research question about the significance of NPLs in bank efficiency analysis. Several studies support the hypothesis that NPLs have an impact, not only on bank efficiency but also on bank stability in terms of solvency.Barros et al. (2012) pointed out that despite knowing the effect of NPLs on bank efficiency, the empirical and methodological research has been limited in comparison to other fields such as environmental and energy research. In research, there are studies, which have treated NPLs as a control variable and then analysed the impact of NPLs on bank efficiency using a second-stage regression. While there are studies which have included NPLs as a bad output directly into the production process.

Non-Performing Loans as control variable

Mester (1996) used NPLs as a control variable in a cost function involving a sample of US banks. This is because a large proportion of NPLs may signal that banks use fewer resources than usual in their credit evaluation and loan monitoring process. Besides, NPL is an endogenous risk, which has the biggest influence on bank efficiency estimates. Their results showed that NPLs have a significant negative impact on total cost.Berger and Humphrey (1997, p13) have also found that an increase "in nonperforming loans tend to be followed by decreases in measured cost efficiency, suggesting that high levels of problem loans cause banks to increase spending on monitoring, working out, and/or selling off these loans, and possibly become more diligent in administering the portion of their existing loan portfolio that is currently performing". These findings have been confirmed by the other researchers (Fries and Taci, 2005; Podpiera and Weill, 2008). NPLs measure management behaviour through bad luck or bad management hypotheses introduced by Berger and Humphrey (1997) and Williams (2004).

Non-Performing Loans in production process

The main limitation of these studies is that they use NPLs as a control variable instead of an undesirable output that directly affects the production process. Berg et al. (1992) used the variable 'loan losses' as an undesirable output in the model that measures the quality of loan evaluations. They measure bank productivity in the Norwegian banking sector by applying the Malmquist index. The quality of loan evaluations is measured through loan losses that are used as an additional output in the model.Park and Weber (2006) followed the same approach and included NPLs directly in the production process. They used a directional technology distance function on a sample of Korean banks and treated NPLs as an undesirable by-product output arising from the production of loans.Fukuyama and Weber (2008)investigated the efficiency and shadow prices for NPLs, using a sample of Japanese banks for the period from 2002 to 2004. They estimated the directional output distance function by applying DEA and a parametric linear method. They argued that NPLs should be treated as fixed input because NPLs are a by-product of the loan production process. They concluded that NPLs should not be ignored in the efficiency analysis of Japanese banks. Finally,Barros et al. (2012) also showed that including NPLs in the production process provides bank managers and regulators with an additional dimension in their decision process. They estimated the technical efficiency by using the Russell directional distance function that takes into consideration not only desirable outputs but also an undesirable output that is represented by NPLs. They found that NPLs caused an overall increase in inefficiency levels.

Assaf et al. (2013) shows that NPLs have to be incorporated in the production process, otherwise the results are biased. For example, when a standard estimation of bank performance is considered, i.e. without including NPLs directly in the model, then a high performing bank is not necessarily better than other banks, as it might be doing that at the expense of producing a high percentage of undesirable outputs. Thus, a production process must be clearly defined based on both desirable and undesirable outputs; using only desirable outputs will fail to credit a bank for its effort to reduce undesirable outputs Guevara and Maudos (2002). Furthermore, Fujii et al. (2014) used an innovative methodological approach introduced by Chen et al. (2014) and Barros et

al. (2012), who use a weighted Russell directional distance model (WRDDM) to measure the technical inefficiency of Indian banks by incorporating NPLs as an undesirable output. They modify and extend the model by measuring total factor productivity change. They showed that NPLs cause technological regress. This is because of the traditional problems faced by Indian banks, which affect their efficiency and productivity. This includes factors such as high levels of NPLs, poor restructuring, management failing, and the lack of market power.

3.3 Bank Liquidity

3.3.1 Role of Liquidity

Banks create liquidity on both sides of their balance sheets by financing long-term projects with relatively liquid liabilities such as transaction deposits and short-term funding. The associated exposure to liquidity risk is an essential characteristic of the bank, which serves as a discipline device and supports efficiency in the financial intermediation (Vazquez and Federico, 2015). This means that bank capital entails a cost in terms of liquidity creation. But, it provides a buffer against changes in the value of bank assets. As a result, increasing the bank's survival probabilities during distressed market conditions. The recent crisis has led to the role of bank liquidity greater attention. The banks were highly reliant on the short-term wholesale funding to finance the expansion of their balance sheets in the run-up to the crisis. Berger and Bouwman (2008) showed that the banking crisis in the U.S. had preceded by periods of abnormal liquidity creation. Liquidity creation exposes the bank to risk- the greater the liquidity created, the greater are likelihood and severity of losses associated with having to dispose of illiquid assets to meet customers' liquidity demand. There is evidence, which shows that the banks' reliance on wholesale funding had a negative effect on the performance of their stock prices after the outbreak of the crisis (Vazquez and Federico, 2015). Furthermore, this contributed to increasing the financial fragility of the banks. This because of the volatility of bank stock returns or by the likelihood of receiving public assistance.

3.3.2 Types of Liquidity Risk

Liquidity risk has been considered as a significant threat to financial institutions and financial system stability. Generally, banks are advised to maintain a liquidity buffer to protect themselves from liquidity risk and small liquidity shocks. The academic literature distinguishes the liquidity risks of the financial system between three types, namely funding liquidity risk, market liquidity risk, and central bank liquidity risk (Nikolaou, 2009). Funding liquidity risk refers to the possibility when a bank will be unable to face its current and future financial obligations because it is unable to get access to the funding. Therefore, daily operations are negatively impacted. Market liquidity risk refers to the danger that a bank will be unable to perform a large operation on the market without influencing the price of the assets sold.If manifested, the prices of the assets sold by the bank drop rapidly, making the bank in the end insolvent. Central bank liquidity risk represents the inability of this institution to supply the liquidity needed to the financial system.

Hong et al. (2014) using the data for U.S. commercial banks over the period 2001-2011 showed that the systematic liquidity risk was a significant contributor for the bank failures occurring over 2009-2010 in the aftermath of the Global Financial Crisis. Furthermore, they showed that liquidity risk could contribute to bank failures through systematic and idiosyncratic channels.Vazquez and Federico (2015) found that higher funding stability as measured by Net Stable Funding Ratio(NSFR) featured in the Basel III would be reducing the probability of bank failures. NSFR reflects the proportion of long long-term illiquid assets that are funded with liabilities that are either long-term or deemed to be stable. A higher NSFR is associated with lower liquidity risk because large weights are assigned to less liquid assets and liabilities. Further, King (2013) showed that to maintain a higher NSFR, banks would have to pay higher interest expenses for borrowing more long-term funds. NSFR is designed to encourage banks to hold more high quality, unencumbered, liquid assets, and to increase funding from stable sources such as deposits, longer maturity debt, and equity. This would be to increase the resilience of the banks during a stressful period. The banks would be having lower profitability during normal times because holding fewer illiquid assets and more high-quality assets that cannot be pledged as collateral will lower interest income. Funding assets with

longer maturity liabilities will increase interest expense. The resulting decline in net interest income combined with the increase in interest-earning assets will cause Net Interest Margins to decline.

Funding Liquidity Risk

Funding liquidity risk is negatively related to market liquidity (Drehmann and Nikolaou, 2013). A drying up of market liquidity depresses the value of assets, which can be sold to raise funds. This raises the funding liquidity risk of the banks. Banks are required to hold a certain amount of deposits as their liquidity reserve with the central bank in the form of high-quality liquid assets. Over time, the funding liquidity levels fluctuate for the banks. Therefore, there are concerns that high liquidity levels might contribute to the financial crisis(Khan et al., 2017). In analysing aggregate financial sector liquidity,Adrian and Shin (2010) noted that to utilise the excess capacity which comes from balance sheet growth, financial intermediaries will look for potential borrowers even if the borrowers are not having the resources to repay the loan. Aggregate liquidity can be interpreted as the rate of growth of the aggregate financial sector balance sheet. Generally, when asset prices increase, financial intermediaries' balance sheets become stronger and their leverage tends to be low. As a result, the financial intermediaries hold surplus capital and attempt to find ways to employ their surplus capital. For utilising this surplus capacity, the balance sheet must expand. On the liability side, banks take on more short-term debt. On the asset side, they search for potential borrowers. Aggregate liquidity is intimately tied to how hard the financial intermediaries search for borrowers (Adrian and Shin, 2010). The sub-prime mortgage crisis is an example of how aggregate liquidity could cause a crisis.Therefore, the higher levels of aggregate liquidity could be the cause of the financial crisis.Wagner (2007) used theoretical models for investigating the relationship between the liquidity of bank assets and banking stability. He found that increased liquidity of the bank assets reduces banking stability during the financial crisis. However, this does not take place during normal times. An increase in liquidity within the banking sector could result from increases in interest rates by changes in the monetary policy.Lucchetta (2007) showed that the banks took more risk when risk-free interest rates increased because of greater investment in risk-

free bonds. This contributes to an increase in liquidity supply in the interbank market and encouraging more interbank lending. Additionally, the increased liquidity supply boosts other bank's investment in risk assets. Therefore, both the theoretical and empirical literature suggests that banks' funding liquidity risk is closely related to bank risk-taking.

Diamond and Rajan (2005) building on the model developed in Diamond and Rajan (2001) explained that if there are too many distressed economic projects funded by loans the bank cannot meet the depositor's demand. If these assets deteriorate in value, more and more deposits will start claiming their money. The main result is that higher credit risk accompanies higher liquidity risk through depositors' demand. Rollover risk arises when pre-existing debt obligations become due and the resulting liquidity needs are potentially unmet. The reliance on short-term liabilities by requiring a continuous rollover of expiring debt is by itself responsible for exposing financial institutions to higher default risk.Acharya and Viswanathan's(2011) model is based on the assumption that the financial firms raise debt that has to be rolled over constantly. This is used to finance assets. They showed that more debt in the banking system results in higher bank run risk. During the crisis, when asset prices deteriorate, the banks find it very difficult to roll over the debt because of the liquidity problem.He and Xiong (2012) focussed on the debt rollover risk. They stated that the debt maturities of lenders on short-term debt are spread across time and rolled over to avoid bank-run risk if all debt contracts expire at the same time. They derived an equilibrium in which each lender will not roll over the debt contract if the fundamental asset value falls below a certain threshold. They found that lenders are more likely to run if the asset values decrease. During the crisis, the asset price volatility tends to spike; the rising volatility is an important source of instability in the financial firms.

The Global Financial Crisis showed the distrust between banks, which was largely driven by credit, risks in their portfolio. This could cause a freeze in the market for liquidity. Therefore, regulators and central banks had to intervene to prevent the collapsing of the financial system.Imbierowicz and Rauch (2014) using US commercial banks data during the period 1998-2010 to investigate the relationship between Liquidity Risk and Credit Risk and how this relationship influences banks' probabilities of default. They found that

both Liquidity Risk and Credit Risk have a strong influence on the bank's default risk. They showed that joint management of liquidity risk and credit risk in a bank could increase bank stability. A bank facing a default has two options: First, to continue running the failed business model until the point of default is reached or second, to engage in a high-risk business, which carries great rewards but also great risks. The risks are negligible because without the high-risk business activity the bank would very likely face elimination anyway. The only thing saving the bank from failure is an improbable but potentially very high payoff from the risky business. As a result, banks increase their liquidity risks and credit risks jointly in a last effort to avoid default. During the recent crisis, distressed banks might have engaged in this practice.

Ghenimi et al. (2017) using a sample of 49 banks operating in the MENA region over the period 2006-2013 to analyse the relationship between credit risk and liquidity risk and its impact on bank stability. They found both liquidity risk and credit risk separately influence bank stability and their interaction contributes towards the bank instability. Especially, the effect of liquidity risk is harmful to the stability of banks when the credit risk is high, and vice versa. Also, banks with lower liquidity risk relative to the ones with higher liquidity risk charge higher banking stability as their credit risk increases. This is because sufficient liquidity enables these banks to maintain their stability. If the interaction between liquidity risk and credit risk were negative, this would decrease the banking stability during the financial and economic crisis because, during the crisis, banks are subject to higher loan rates. Therefore, exposed to larger credit risk.Gorton and Metrick (2012)showed how a bank run based on the investor panic happened in modern-day securitized banking, as opposed to bank runs in traditional banking. Their evidence suggested that in the recent Global Financial Crisis perceived credit risk in the form of subprime loans caused refinancing rates and funding haircuts in the interbank market to increase substantially.

3.4 Efficiency

3.4.1 Cost Efficiency

According to Andries and Ursu (2016), the term efficiency for banks means improved profitability, the greater amount of funds channelled in, better prices and services quality for consumers, and greater safety in terms of improved capital buffer in absorbing risk. Bank efficiency is measured by a bank's ability to convert its inputs into output while maximising profits or minimizing costs (Belke et al., 2016). A bank would be considered inefficient if it is using numerous inputs or allocating inputs in the wrong proportions. This measurement of efficiency is least affected by endogeneity criticism than financial volume measures due to the bank's ability to covert its inputs should influence growth independently of whether the economy is growing fast or slowly (Belke et al., 2016). An efficient bank should be looking to support the growth of an economy by carefully choosing the optimal projects for funding and assigning the optimal costs with the risks at the same time (Belke et al., 2016). It is significant for banks to prove their efficiency and increase their performance to remain competitive in today's competitive environment. Improving efficiency is significant for the banks because efficiency has a direct impact on the performance and profitability of the bank((Xu et al., 2015).

The deepening of the recent crisis and continued banking fragilities led to banks requiring state support arrangements. This contributed to creating the need for a reassessment of the banking systems' performances. The research on the performance of the financial institutions has focused especially on the frontier efficiency (Andries and Ursu, 2016). The frontier efficiency measures the performance deviations of some companies from the efficiency frontier, which is already, made using the best practices. Additionally, it measures how efficient the financial institution is compared to the most efficient institutions on the market. The frontier efficiency quantifies the cost efficiency of financial institutions with greater precision than financial rates(Andries and Ursu, 2016). The information obtained can be used to guide the government policy by assessing the effects of deregulation, mergers, or market structure on efficiency, and to improve managerial performance by identifying best and worst practices associated with high and low measured efficiency. For banks, effi-

ciency implies improved profitability, the greater amount of funds channelled in, better prices and services quality for consumers and greater safety in terms of improved capital buffer in absorbing risk.

Allocative efficiency refers to the ability of the bank to use the optimum mix of inputs given their respective prices. Cost Efficiency is the product of Technical Efficiency and Allocative Efficiency. Cost Efficiency shows the ability of the bank to provide services by optimum use of the resources at its disposal. Allocative Efficiency or Technical Efficiency provides guidance for the bank to become more cost efficient and helps in reducing the wastage of the resources. Cost Efficiency helps in indicating how close a bank's cost is to that a best practice bank's cost would be producing the same outputs under the same conditions (Pasiouras et al., 2009). Therefore, Cost efficiency is considered as a wider concept than technical efficiency. Cost Efficiency refers to both technical efficiency and allocative efficiency.

3.4.2 Risk and Efficiency

A risk-averse bank may choose to fund its loans with a higher ratio of financial capital-to-deposits than a risk-neutral bank. This is because financial capital is usually more expensive than deposits. This could make one conclude that risk-averse bank produces its output in an allocative inefficient manner (Sun and Chang, 2011). However, it is actually the risk-preferences, which differ. For controlling these differences in the risk-preferences,Mester (1996) asserts that the level of financial capital to be included in the cost function. This is because the risk-averse bank could still be characterised as minimising cost, given the level of financial capital. Also, the financial capital should be accounted for in the cost function because the cost-minimisation does not fully explain a bank's capital level. For example, the regulators set minimum capital-to assets ratios, and banks may be risk-averse.

Altunbas et al. (2000) investigated the impact of risk and quality factors on bank efficiency for the banks in Japan between 1993 and 1996. For controlling the risk, they use loan loss provisions and financial capital. They found that the optimal bank size is considerably smaller when risk and quality factors are taken into account when modelling for the cost characteristics of Japanese banks. Further, they found that the level of financial capital has the largest in-

fluence on the scale efficiency estimates. During the period of study, Japanese banks experienced a decline in their capital strength whereas the changes in loan loss provisions were modest. The financial capital has the biggest influence on determining optimal bank size.Iannotta et al. (2007) compare the performance and risk of a sample of 181 large banks from 15 European countries over the 1999-2004 period and evaluate the impact of ownership models on their profitability, cost efficiency, and risk. They show that the public sector banks are less profitable and have higher insolvency risk than privately owned banks. The public sector banks poorer loan quality. This result is consistent with the existence of conjectural or explicit government guarantees which allow these banks to avoid indirect costs – in terms of capital markets effects – of their poorer asset quality and less profitable intermediation activity. Furthermore, they showed that mutual banks have better loan quality and lower asset risk than both private and public sector banks. The mutual banks enjoy more favourable customer relationships which also explains their lower operating costs.

Gonzalez (2005) investigated the impact of bank regulation on bank charter value and risk-taking for 36 counties over 1995-1999. He used the ratio of non-performing loans to total bank loans as a measure for the credit risk and measures overall risk with the standard deviation of daily bank stock returns. He found that regulatory restrictions increase banks' risk-taking incentives by reducing their charter value. The higher charter value of banks in countries with fewer regulations may increase the incentives for these banks to act more prudently. Therefore, more lax regulation could be associated with greater stability of the banking system.Chiu and Chen (2009) investigated the bank efficiency in Taiwan for 29 banks from 2002 to 2004. They not only incorporate credit risk but also, market and operational risk factors such as the foreign exchange rate, the interest rate, and the economic growth. They found that the influence of external environmental risk to be the largest for the privately-owned banks when compared with the publicly-owned banks. The performance of the publicly-owned bank is better than privately owned banks because publicly-owned banks have operated over a long period of time and have more trust from their customers.

In the existing literature, there are only a few studies which examined

how ROA's(Return on Asset's) volatility affects the bank efficiency.Berger and Humphrey (1997) using the data on the US banks for the period 1990-1995. They found that the standard deviation of ROA is negatively associated with the cost efficiency of the bank. Furthermore, they found a similar relationship between the standard deviation of Return on Equity (ROE) and the cost efficiency of the bank. This may provide evidence on the extent to which the measured cost inefficiencies incorporate the differences in product quality. In a competitive market, the differences in product quality are rewarded with higher revenues which covers the costs, the alternative profit inefficiency essentially just improves on cost efficiency by offsetting the extra costs of producing higher quality with higher revenues. However, some of the recent studies using the international data found some contradicting results than the earlier findings for the U.S. Isik and Hassan (2002) using the data on the banks in Turkey over 1988-1996 period found that the standard deviation of ROE to be positively related to the cost efficiency of banks. Similarly,Havrylchyk (2006) investigated the efficiency of the Polish banking industry between 1997 and 2001. She showed that the volatility of ROA significantly affects the cost efficiency of the bank positively. Furthermore, she found a positive correlation between ROA and the variance of ROA. This indicates that riskier banks to be not only more efficient but also more profitable on average. If there is a trade-off between risk and efficiency, then banks that are poor at operations might also be poor at risk management. Also, inefficient banks tend to hold higher risk in stock returns. This means that the inefficient bank's stock tends to underperform than their more efficient counterparts.

Fiordelisi et al. (2011) investigated the intertemporal relationship between bank efficiency, capital, and risk in a sample of European commercial banks for the period 1995 to 2007. They found that bank capital precedes cost efficiency improvements. Further, they suggest that moral hazard incentives are reduced for the banks because of an increase in the bank capital. This indicates that better-capitalized banks are more likely to reduce their costs compared to less-capitalized banks.Chortareas et al. (2011) examined the dynamics between financial frictions, efficiency, and risk for Eurozone's commercial banks from 1999 to 2004. They found that deposit insurance schemes could contribute to reducing bank risk and promote competition among banks. Therefore, it would

be improving the efficiency in the banking industry. This is consistent with the agency cost hypothesis that higher capital ratios and deposit insurance coverage are associated with higher efficiency. The higher levels of capital ratios may prevent moral hazard and alleviate informational frictions, leading to more efficient financial institutions. The higher capital creates an incentive for the shareholders to monitor the managers. The higher deposit coverage limit protects small depositors who lack the resources to evaluate the soundness of banks and enhance rivalry by allowing small banks to compete for depositors with their larger counterparts. As a result, a higher deposit coverage limit would stabilize the banking sector by reducing the risk of bank runs. This would enhance the efficiency of the banks.

3.4.3 Bank Cost Efficiency using Stochastic Frontier Analysis

For measuring the efficiency in the banking sector, there are two prevailing techniques:- the Non-parametric method and the parametric method. Data Envelopment Analysis(DEA) is one of the non-parametric techniques. Stochastic Frontier Analysis (SFA) is a parametric method. In the Banking sector, Stochastic Frontier Analysis(SFA) is used to estimate the cost efficiency of the banks.

Yeh (2011) investigated the cost efficiency of the banks in Taiwan using SFA over the period 1999-2000. The results showed the average cost efficiency was 72.69%, which is inefficient. It was found that the banks in Taiwan engaged in mergers to improve their efficiency. In addition, it was found that the main positive determinants were debt ratio.Shamsuddin and Xiang (2012) investigated the efficiency of the Australian Banks using SFA for the period 1995-2008. They found that the cost efficiency improved in large and small banks. Additionally, the larger banks were found to be more cost efficient than smaller banks.

Yildirim and Philippatos (2007) investigated the cost efficiency in the banking sectors of Central and Eastern Europe for the period 1993-2000. The sample consisted of 325 banks. Using SFA, they found the cost efficiency to be 77%. According to cost efficiency's determinants, size, capitalisation, loans, foreign ownership and GDP supported efficiency positively and significantly

whereas, loan loss reserves decreased efficiency.Fries and Taci (2005) investigated the cost efficiency of banks in 15 Eastern European countries during the period 1994-2001. Using SFA, their results indicated that the overall cost efficiency of the banks was low. The highest average cost efficiency was found to be in Estonian banks and the lowest in Romanian banks. Also, they found the private banks to be more efficient than state-owned banks due to deregulation. They concluded that for improving the efficiency, the banks had to take a position of competition against the European Union countries and the banks to reduce their costs and raise their profits through planned strategies and policies. Turk Ariss (2008) explored the cost efficiency of Lebanese commercial banks during the period 1990-2001 using SFA. He found that from 1996 to 2001 banks were more efficient because of more liberalisation such as deregulation. The average cost efficiency for the period of 1996-2001 was 97.06% , whereas, for 1990-1995, it was 85.33%. This shows that banks improved their cost efficiency during the period of the study. The average cost efficiency was found to be relatively low due to the war in the country.

Using SFA,Vu and Turnell (2011) analysed the cost efficiency of Australian banks for the period 1997-2009. They divided their study into two periods, pre-global financial crisis from 1997-2006 and during the global financial crisis from 2007-2009. They found major banks to be more cost efficient than the regional banks. Before the global financial crisis, the major banks' cost efficiency score was 69.1% whereas regional banks scored 72.3%. During the global financial crisis, the cost efficiency score for major banks was 70.1% and for regional banks was 68.6%. The results indicated that banks with lower size and capital to be more efficient. They found that profitability ratios such as Return on Equity and Net Interest Margins had a negative relation with the efficiency. Additionally, non-interest expenses affected cost efficiency negatively.

Holló et al. (2006) investigated the cost efficiency of the banks in 25 EU member states from 1999 till 2003. They reported the efficiency scores generated by both the controlled and uncontrolled models. The uncontrolled model contains only inputs and outputs whereas the controlled model is expanded with the country-specific variables such as inflation, depth of financial intermediation, market concentration, level of liberalisation, and banking reform. In the controlled model, the variation in average bank efficiency across the

countries diminishes and efficiency scores are higher. However, the relative efficiency rankings of the countries do not change much between the controlled and the uncontrolled models.

Numerous studies have included the time effects in the estimation of the cost efficiency frontier. These studies have found a positive and significant increase in the efficiency over time for the overall sample of the banks. Weill (2007) compared the efficiency of the bank from Western European countries and Central and Eastern European countries to assess the performance gap between both groups of banks. He measured the cost efficiency of a sample of 955 banks from 17 European countries with SFA. The results show that the efficiency improved between 1996 and 2000 for the banks in Eastern European countries. The efficiency improved for all the countries in the sample. However, the increase in efficiency was higher for banks in Eastern European countries than the banks in Western European countries. In addition, the efficiency gap increased for the banks in Poland and Slovenia.Kasman and Yildirim (2006) analysed the cost efficiency of commercial banks in eight Central and Eastern European countries that became new members of the European Union over the period 1995-2002. They found that the average estimated cost efficiency scores do not fluctuate much during the sample period, reaching the minimum in 2001 (18.5%) and the maximum in 1998 (21.7%). Additionally, there is not any uniform trend in the evolution of efficiency in individuals. As the cost inefficiency seems to have upward trends in Hungary and Slovak Republic, while it has a downward trend in Latvia. For the other countries there does not seem to be any clear trend in the efficiency scores over the analysed period.Pasiouras et al. (2009) used SFA to investigate the impact of regulatory and supervision framework on the cost efficiency of banks in 74 countries during the period 2000-2004. They found the overall mean cost efficiency to be 0.8789. This means that the average bank could reduce its costs by 12.11%. Over the estimation period, the efficiency scores decreased each successive year from 0.8899 in 2000 to 0.8685 in 2004.

Goddard et al. (2014) analysed the cost efficiency for Latin American banks between 1985 and 2010. The results indicate that the average cost efficiency to have deteriorated between 1985-1993 and 1994-2004. This was noticeable, especially for the state-owned banks. Prior to 2006, Latin America witnessed

a widespread foreign bank expansion. This reflects an improved operating environment. As a result, the cost efficiency improved throughout this period. Using SFA, Lozano-Vivas and Pasiouras (2010) explored the relevance of non-traditional activities in the estimation of the bank efficiency for 752 commercial banks from 87 countries for the period 1999-2006. They found that the inclusion of non-traditional activities does not significantly influence the directional impact of environmental conditions on cost inefficiency. However, environmental factors lead to higher efficiency when non-traditional activities are taken into consideration. Also, they found that regulatory conditions that enhance banking supervision and monitoring, and regulations that restrict bank activities, generally contribute to improvement in bank efficiency.

Sun and Chang (2011) employed a heteroscedastic stochastic frontier model for estimating the cost efficiency of banks in eight emerging Asian countries for the period 1998-2008. Using the heteroscedastic stochastic frontier model allows us to investigate the non-monotonic effects on efficiency. They found the effect of interest rate volatility on the banks of Indonesia, Malaysia, and Thailand to have a non-monotonic pattern. Except for Indonesia and Taiwan, they found an upward trend for the cost efficiency over the years for most emerging Asian countries. This showed that these countries have gradually reformed their banking sector since the Asian financial crisis in 1997-1998. The most volatile cost efficiency among the eight countries was in Indonesia. This may be the result of the highest interest rate change/volatility and exchange rate change. Additionally, they found that the marginal effect of risk measures such as Credit Risk, Market Risk, and Operation Risk is not consistent over time. The marginal effect of credit risk maintained a high level for pre-2001 and presented a downturn in 2001-2006. After 2006, this effect increased again. As a result, the negative effect on cost efficiency became a serious concern. The other risk measures negatively affect cost efficiency.

3.5 Methodology

3.5.1 Stochastic Frontier Analysis

In this study, Stochastic Frontier Analysis (SFA) is deployed to measure the efficiency of the banks. The possible reasons for choosing SFA over Data En-

velopment Analysis (DEA) are many. Firstly, DEA does not assume statistical noise. This means that the error term in the estimation is attributed to inefficiency. Hence, DEA accounts for the influence of factors such as regional price differences, luck, bad data, and extreme observations such as inefficiency. Secondly, the efficiency scores measured by DEA in small samples is sensitive to the difference between the number of firms and the sum of inputs and outputs used. Another distinction between these two methods is the assumption of some clearly defined production technology – i.e. a parametric production function. In contrast to DEA, SFA relies on this assumption of the production to be utilized in the analysis of the data, while DEA avoids defining an explicit production function. This contributes to a different interpretation of the results from these methods. SFA estimates the parameters of the production function itself, whereas DEA estimates the convex hull of the technology set as the minimal enveloping frontier.

Aigner et al. (1977) and Meeusen and van Den Broeck (1977) independently proposed the stochastic frontier approach. It modifies the traditional assumption of a deterministic production frontier. Both these studies specified a composed error with two components:- a one-sided error that measures the non-negative inefficiency effects and random factors not controlled by the decision-making unit (DMU). Some studies extend SFA to investigate the determinants of inefficiency among DMUs. These studies assumed that inefficiency effects are a function of some DMU-specific factors Battese and Coelli (1995). The recent efforts modelling heteroscedasticity in inefficiency effects(μ_{it}) considered a model flexible specification in two ways. Kumbhakar et al. (1991) assumes that the mode of μ_{jt} (i.e.,μ_{it}) differs among DMUs.Caudill et al. (1995) assumed μ_{it} to be constant, but allowed the variance of pre-truncated distribution (σ_{it}^2) to be observation-specific.

The single equation stochastic model can be given as

$$TC_{it} = f(Y_{it}, P_{it}) + \epsilon_{it} \tag{3.1}$$

where observed total cost for the ith bank in year t is represented by TC_{it} , Y_{it} is a vector of outputs, and P_{it} is an input price vector.

Following Aigner et al. (1977),we assume that the error of the cost function is

$$\epsilon = \mu + \nu \tag{3.2}$$

where μ and ν are independently distributed.μ is usually assumed to be distributed as half-normal, that is, a one-sided positive disturbance capturing the effects of inefficiency, and ν is assumed to be distributed as two-sided normal with zero mean and variance σ_2, capturing the effects of the statistical noise.

Wang (2002) combines the feature of the traditional models and those extended models above and allows both μ_{it} and σ_{it} to be observation specific. Suppose that total cost for the ith bank in year t are represented by TC_{it} , Y_{it} is a vector of outputs and Pit is an input price vector. The heteroscedastic stochastic frontier model specification for the cost function can be presented as below : -

$$TC_{it} = f(Y_{it}, P_{it}) + \mu_{it} + \nu_{it} \tag{3.3}$$

$$\nu_{it} \sim N(0, \sigma_{it}^2) \tag{3.4}$$

$$\mu_{it} \sim N^{+}(\mu_{it}, \sigma_{it}^2) \tag{3.5}$$

$$\mu_{it} = \delta_0 + Z_{it}\delta \tag{3.6}$$

$$\sigma_{it}^2 = exp(\gamma_0 + Z_{it}\gamma) \tag{3.7}$$

where ν_{it} is the stochastic error term with i.i.d. normal distribution. This model assumes μ_{it} has a truncated normal distribution with an observation-specific mean (μ_{it}) and variance (σ_{it}^2) of its pre-truncated distribution. In this setup, μ_{it}t is the inefficiency effect, which is a non-negative truncation of a normal random variable. The variable vector Z_{it} includes a constant of 1 and some other exogenous variables associated with the inefficiency. The γ and δ are the corresponding coefficient vectors.The heteroscedastic stochastic frontier model assumes μ_{it} and σ_{it}^2 are a function of some determinants(Z_{it}).Lai and Huang (2010) illustrated that this general setting in Wang's(2002) model is the best specification among eight well-known stochastic frontier models.

In this study, we specify a multi-product translog cost function and estimate :

$$\begin{aligned} In\ C_{it} = \alpha_0 + \Sigma_{m=1}^{M}\beta_n In\ w_{nit} + \frac{1}{2}\Sigma_m\Sigma_k\alpha_{mk} In\ y_{mit} In\ y_{kit} \\ + \frac{1}{2}\Sigma_n\Sigma_j\alpha_{nj} In\ y_{nit} In\ y_{jit} + \alpha_{00}t + \frac{1}{2}\alpha_{000}t^2 \\ + \Sigma_m\Sigma_n\alpha_{mn} In\ y_{mit} In\ w_{nit} + \Sigma_m\alpha_{mt} In\ y_{mit}t \\ + \Sigma_n\alpha_{nt} In\ w_{nit}t + \epsilon_{it}(\nu_{it} + \mu_{it}) \end{aligned} \tag{3.8}$$

where C_{it} is the total cost of bank i, y_{mit} is m-th output, w_{nit} is the n-th input price , t is the time trend and α_0 is an intercept accounting for all other cost determinants.. The components of composite error term, ϵ_{it} $(\nu_{it} + \mu_{it})$, μ_{it} captures the cost inefficiency and ν_{it} is a random error.

The use of duality implies the necessity to impose the following homogeneity restrictions :

$$\Sigma_{n=1}^{N}\beta_n = 1 \tag{3.9}$$

As in Lang and Welzel (1996), in this study, we normalise total costs and input prices by the price of labour. We estimate firm-specific efficiency scores as the conditional expectation of μ_{it} given by ϵ_{it} (Jondrow et al., 1982).

$$Efficiency = exp\ E[\frac{-\mu_{it}}{\epsilon_{it}}] \tag{3.10}$$

It takes on the values between 0 and 1, where the latter indicates a fully efficiency bank. The value indicates the percentage of observed costs that would have been sufficient to produce the observed output if the bank was fully efficient.

A special feature in Wang's 2002 model is that it allows the determinants (Z_{it}) to have non-monotonic effects on the inefficiency effect (μ_{it}). By non-monotonic effects, it means that Z_{it} can have both positive and negative effects on the efficiency and that the sign of the effect depends on the values of Z_{it}. The traditional SFA models implicitly assume that the determinants have strictly increasing or decreasing effects on the inefficiency effect. In Wang's (2002) model,Z_{it} can positively(negatively) affect the mean and variance of the inefficiency effect when values of Z_{it} are within a certain range, and then turn negative (positive) for values of Z_{it} outside the range. Such non-monotonic effects are measured by the marginal effects. The ability to accommodate

non-monotonic effects is significant for models seeking to understand the relationships between efficiency and exogenous factors. This is because many of the relationships between economic variables are indeed non-monotonic.

To demonstrate non-monotonicity, our strategy is to show that the marginal effect of Z(k) on E(μ_{it}) and/or V(μ_{it}) can be both positive and negative in the sample. If the signs can alternate in the sample, then this implies that the impacts of Z(k) can go in both directions. The first two moments of the mean and the variance of μ_{it} as follows :

$$m_1 = f(\mu_{it}, \sigma_{it}) = \sigma_{it}[\wedge + \frac{\phi(\wedge)}{\Phi(\wedge)})] \tag{3.11}$$

$$m_2 = g(\mu_{it}, \sigma_{it}) = \sigma_{it}^2[1 - [\frac{\phi(\wedge)}{\Phi(\wedge)}] - [\frac{\phi(\wedge)}{\Phi(\wedge)}]^2] \tag{3.12}$$

where $\wedge = \frac{\mu_{it}}{\sigma_{it}}$, and ϕ and Φ are the probability and cumulative density functions of a standard normal distribution, respectively.

Taking into account the parameterization functions (3.6)and (3.7), the non-monotonic efficiency effects on E(μ_{it}) of the jth element on Z_{it} can be estimated as follows :

$$\frac{\vartheta E[\mu_{it}]}{\vartheta z[j]} = \delta[j][1-[\frac{\phi(\wedge)}{\Phi(\wedge)}]-[\frac{\phi(\wedge)}{\Phi(\wedge)}]^2+\gamma[j]\frac{\sigma_{it}}{2}[(1+\wedge^2)[\frac{\phi(\wedge)}{\Phi(\wedge)}]+[(\wedge)(\frac{\phi}{\Phi}]^2)] \tag{3.13}$$

where $\wedge = \frac{mu_{it}}{\sigma_{it}}$, and ϕ and Φ are the probability and cumulative density functions of a standard normal distribution, respectively.z[j] is the jth element of Z_{it} , and $\delta[j]$ and $\gamma[j]$ are the corresponding coefficients in the equation (3.6)and (3.7). The equation shows that the marginal effect is the sum of the adjusted slope coefficients from the mean and the variance functions.

Additionally, the marginal effect of Z_{it} on V(μ_{it}) can be represented as :

$$\begin{aligned}\frac{\vartheta V[\mu_{it}]}{\vartheta z[j]} = (\frac{\delta(j)}{\sigma_{it}})[\frac{\phi(\wedge)}{\Phi(\wedge)}](m_1^2 - m_2) + \gamma[j]\sigma_{it}^2 \\ [1 - \frac{1}{2}[\frac{\phi(\wedge)}{\Phi(\wedge)}](\wedge + \wedge^3) + (2 + 3\wedge^2 \\ [\frac{\phi(\wedge)}{\Phi(\wedge)} + 2 \wedge [\frac{\phi(\wedge)}{\Phi(\wedge)}]^2)]\end{aligned} \tag{3.14}$$

where m_1 and m_2 are the first two moments given in (3.11)and(3.12) , respectively. The marginal effect is the sum of the adjusted slope coefficients. Based on a result from Barrow et al. (1954),Bera and Sharma (1999) state

that $m_1^2 - m_2 > 0$. For the models with constant σ_{it}^2 , the effect of z[j] is again monotonic , and the effect can be non-monotonic when σ_{it}^2 is parameterized.

3.5.2 Data and Variables

The recent financial crisis highlighted the problems in the banking system. The commercial banks plays a significant role in the banking system. Furthermore, the commercial banks are an important part of the economy.This is because they not only do they provide consumers with an essential service, but they also help create capital and liquidity in the market.Commercial banks play a role in the creation of credit, which leads to an increase in production, employment, and consumer spending.As a result, boosting the economy.The commercial banks are heavily regulated by the regulators. Therefore,the focus of this study is on commercial banks. This would allow examining a more homogeneous sample in terms of services and consequently inputs and outputs enhancing further the comparability among countries. Additionally, it will allow to examine how the risk measures impact on the cost efficiency of the banks because the efficiency of the commercial bank is essential for banks stability.

The financial data for the banks is available from Market Intelligence for the period 2010-2018.The banks are excluded from the sample if they had no data available for any of the years.During the above procedure, we select the consolidated data only. The reports prepared under International Financial Reporting Standards are used where available, but if only reports prepared under local generally accepted accounting principles are available, then it is used. All the data was converted to the Euro prior to downloading, using official exchange rates available in Market Intelligence. The sample consists of 2630 banks in 147 countries.

The sample is subdivided into six groups.The subdivision of the bank is based on the geographical region of the bank. The six groups based on the geographical region are - Africa, Asia-Pacific, Europe, Latin America, Middle East, and the United States and Canada. This classification is done by Market Intelligence based on the geographical region of the bank.In the final sample,the study has 2630 banks from 147 countries across the six regions for the period 2010-2018.

The review of the cross-country studies indicates that the intermediation approach is most commonly used. This is consistent with the modern empirical literature of studies which examines individual countries. Following these studies, the intermediation approach is adopted. The model is estimated using 4 outputs and 2 input prices. The output variables are specified as Total Loans, Other Earning assets, Total Deposits, and Liquid Assets. The Other Earning Assets comprises of advances to banks, derivatives, and other securities. In the literature, the quality of loans has received a lot of attention in recent years. Therefore, loan loss provisions are subtracted from total loans in order to ensure that this output entails comparable quality (Havrylchyk, 2006).Accordingly, input prices are defined as follows. Price of funds (PF) defined by the ratio of interest expenses to total deposits; the Price of labour (PL) measured by the ratio of personnel expenses to total employees. The total costs of each bank consist of interest expenses and non-interest expenses. These variables have been used in the previous literature, such as Berger et al. (2009) ,Altunbas et al. (2001), Lensink et al. (2008) and Sun and Chang (2011)Sun and Chang(2011).

Table 3.1: Description of Output ,Input Prices and Total Cost Variables.These variables are used in SFA.Output variables are:-Loans,Other Earning Assets,Total Deposits and Liquid Assets.Input Prices are Price of funds and Price of Labour.

Variables	**Description**	**Remarks**
Loans	Gross Loans – Loan Loss Provisions	Total Loans
OEA	Advances to banks, Derivatives and other securities	Other Earning Assets
TD	Total Deposits	Total Deposits
LA	Total Liquid Assets	Total Liquid Assets
PF	Total interest expenses / Total deposits	Price of Funds
PL	Personnel Expenses / Total Employees	Price of Labour
TC	Interest Expenses + Non-Interest Expenses	Total Costs

In this study, we look into the relationship between the bank's cost efficiency and different risk sets such as Non-Performing Exposures, Liquidity Risk, and Funding Liquidity Risk. The ratio of Non-Performing Exposure(NPE) is measured as the sum of outstanding non-performing loans, advances, and debt securities divided by the gross carrying amount of loans, advances, and debt securities. The Liquidity Risk(LIQ) is measured as the ratio of the liquid assets to total assets. The Funding Liquidity Risk(FLIQ) is

measured as the ratio of total deposits to total assets (Khan et al., 2017).

Table 3.2: Description of the Risk Variables.These variables are used in SFA.The risk variables :- Non-Performing Exposures,Liquidity Risk and Funding Liquidity Risk.

Variables	Description	Remarks
NPE	Outstanding Non-Performing Loans,Advances and Debt Securities/Gross carrying amount of Loans,Advances and Debt Securities	Non-Performing Exposures
LIQ	Liquid Assets/Total Assets	Liquidity Risk
FLIQ	Total Deposits/Total Assets	Funding Liquidity Risk

3.6 Results

3.6.1 Descriptive Statistics

Table 3.3 shows the descriptive statistics of the variables used in the cost function. On average, Asia-Pacific, and the United States and Canada have the highest loans while Africa, and the Middle East have the lowest loans. However, Europe has one of the maximum amounts of loans after Asia-Pacific. On average, only Africa and Latin America have Other Earning Assets more than the average of all the global regions combined. On average, only Asia-Pacific and the United States and Canada have a maximum amount of Deposits and Liquid Assets which is greater than the average of all the global regions combined. The price of funds is highest in Latin America and the Caribbean whereas Europe and Asia –Pacific have the least. This reflects the inflation issue, which has been an on-going issue in Latin America. The United States and Canada on average are most expensive in terms of labour. This is higher than the average of all the global regions combined. While Africa and Latin America and Pacific are least expensive in terms of labour on average. On

Table 3.3: Descriptive Statistics of the Variables used in the cost function.SFA is used for calculating efficiency.Output variables are:-Loans,Other Earning Assets,Total Deposits and Liquid Assets.Input Prices are Price of funds and Price of Labour.TC is Total Cost.The sample period is 2010-2018.The sample consists of 2630 banks.Reported statisitcs are:-mean,standard deviation,minimum and maximum. Reported figures are in €millions.

Global Region	Variable	Loans	OEA	TD	LA	PF	PL	TC
Africa	Mean	2511.525	9857.054	2660.201	111000	0.000	0.005	4240.298
	Std. Dev.	9367.182	63100	9118.062	484000	0.000	0.020	18500
	Min	0.000	0.000	0.001	112.351	0.000	0.000	0.001
	Max	65400	703000	71400	6610000	0.000	0.134	193000
Asia-Pacific	Mean	27400	3265.144	35200	1730000	0.000	0.009	29200
	Std. Dev.	112000	15500	145000	7520000	0.000	0.042	351000
	Min	0.004	0.000	0.002	0.066	0.000	0.000	0.000
	Max	1410000	197000	2070000	80100000	0.000	0.465	9820000
Europe	Mean	10500	3345.054	8880.119	678000	0.000	0.009	54200
	Std. Dev.	50900	25800	47300	5280000	0.000	0.062	3430000
	Min	0.008	0.000	0.000	0.024	0.000	0.000	0.000
	Max	873000	515000	778000	113000000	0.000	1541.114	266000000
Latin America and Caribbean	Mean	8852.955	4026.052	13000	755000	0.000	0.004	3002.489
	Std. Dev.	33900	25400	101000	6940000	3.277	0.012	21600
	Min	0.000	0.000	0.000	0.001	0.000	0.000	0.000
	Max	634000	416000	2340000	177000000	0.089	0.058	502000
Middle East	Mean	7044.080	2397.713	8571.931	320000	0.000	0.006	15000
	Std. Dev.	14100	7936.894	15700	531000	0.000	0.040	260000
	Min	0.011	0.000	0.004	4930.093	0.000	0.000	0.000
	Max	138000	104000	134000	3450000	0.000	0.370	5960000
United States and Canada	Mean	18700	3052.341	23200	990000	0.000	560.279	2934.354
	Std. Dev.	63700	18200	81600	4030000	0.000	2771.191	11400
	Min	0.007	0.000	0.013	0.273	0.000	0.000	0.000
	Max	418000	277000	590000	34000000	0.000	18600	121000
Total	Mean	13900	3641.885	15300	877000	0.000	0.037	38000
	Std. Dev.	67400	26400	83700	5680000	0.001	641.382	2570000
	Min	0.000	0.000	0.000	0.001	0.000	0.000	0.000
	Max	1410000	703000	2340000	177000000	0.089	18600	266000000

average, the banks in Europe have the highest total costs. On global average Total Costs, the other regions have lower total costs.

Table 3.4 presents the descriptive statistics of Risk and Exposures Variables. On the global average, Africa and Europe have higher Non-Performing Exposures than the rest of the world. A bank in Europe has the highest Non-Performing Exposure. This shows why the authorities in Europe have started focusing on the issue of Non-Performing Exposures. On the global average, the United States and Canada have the least Liquidity Risk. The bank in Europe has the highest Liquidity Risk whereas the bank in Latin America and the Caribbean has the least. The average Global Funding Liquidity Risk is 0.666. The United States and Canada on average have the highest Funding Liquidity

Table 3.4: Descriptive Statistics of the Risk and Exposure Variables.These variables are used in SFA.The risk variables :- Non-Performing Exposures,Liquidity Risk and Funding Liquidity Risk.The sample period is 2010-2018.The sample consists of 2630 banks in 6 regions.Reported statisitcs are:- mean,standard deviation,minimum and maximum. Reported figures are in €millions.

Global Region		NPE	LIQ	FLIQ
Africa	Mean	2.304	33.873	0.684
	Std. Dev.	19.494	16.868	0.152
	Min	0	3.367	0.228
	Max	292.524	93.878	0.936
Asia-Pacific	Mean	0.144	32.876	0.76
	Std. Dev.	1.197	15.784	0.162
	Min	0	0.322	0.04
	Max	44.977	91.389	1.181
Europe	Mean	1.276	31.922	0.617
	Std. Dev.	19.289	18.195	0.211
	Min	0	0.309	0
	Max	890.779	108.894	4.014
Latin America and Caribbean	Mean	0.241	31.305	0.636
	Std. Dev.	0.99	15.391	0.212
	Min	0	0.139	0.03
	Max	12.262	90.603	0.961
Middle East	Mean	0.133	33.462	0.693
	Std. Dev.	0.285	16.788	0.165
	Min	0	6.162	0.004
	Max	2.865	96.139	0.91
United States and Canada	Mean	0.065	26.07	0.794
	Std. Dev.	0.21	12.908	0.087
	Min	0	2.853	0.382
	Max	3.598	93.358	0.959
Total	Mean	0.889	31.934	0.666
	Std. Dev.	15.113	17.184	0.202
	Min	0	0.139	0
	Max	890.779	108.894	4.014

risk while Europe has the least. However, the bank in Europe has the highest Funding Liquidity Risk. In addition, the individual banks across the world have funding liquidity risk higher than the average global funding liquidity risk. The variability of funding liquidity risk is highest in Latin America and the Caribbean and lowest in the United States and Canada.

3.6.2 The relationship between cost efficiency and risk measures

Table 3.5 provides the results of cost function estimations and the estimated effects of various risk measures on the inefficiency effect. The specifications of the cost function among each model are the same. However, different risk determinants are used to cause different parameters of estimation results. Model 1, 2, and 3 lists three categories of risk: Funding Liquidity Risk, Liquidity Risk, and Non-Performing Exposures. Model 4 presents an essential estimation for all risk measures used in this study. The estimated individual coefficients in the stochastic frontier given by the translog function form are due to many interactions between output and input price variables but unfortunately, they are not directly interpretable, unlike the Cobb-Douglas cost function where all parameters have a clearly specified meaning. The normalisation of variables permits the first-order parameters of the translog function to be directly interpreted as estimates of cost elasticities evaluated at the point of approximation. The model satisfies the homogeneity conditions. λ provides allows testing the validity of the imposed assumptions. It is the ratio of standard deviation attributable to inefficiency relative to the standard deviation due to random noise. λ is highly significant. This implies that the inefficiency prevails in this model. The estimation results show good fit and the signs of the variables are in line with the other studies. The residuals have the correct skewness for the cost efficiency i.e., rightward for the cost efficiency.

The study performs the test for monotonicity using the Spearman Rank Order correlation. Spearman's correlation measures the strength and direction of the monotonic association between two variables. If the Spearman correlation coefficient of a variable is close to 0, it means there is no monotonic relationship between variables. Table 3.5 presents the Spearman's correlation coefficients for the risk measures variable with the inputs, outputs, and total cost. The results show a very weak correlation. This indicates that the monotonic relationship is very weak. Therefore, the study looks into the non-monotonicity effects of the risk measures of efficiency.

In order to measure the cost efficiency of the banks, the study employs SFA. The literature suggests a range of different approaches to model the cost func-

Table 3.5: Spearman Rank Order Correlation for Inputs ,Outputs, Total Cost and the Risk Measures. Inputs are: - Loans, Other Earning Assets, Total Deposits and Liquid Assets. Outputs are: - Price of Funds and Price of Labour. Risk Measures are Funding Liquidity Risk, Liquidity Risk and Non-Performing Exposures.The sample period is 2010-2018.The sample consists of 2630 banks. (***, ** and * indicate 1%, 5% and 10% significance levels, respectively.)

	TC	**Loans**	**OEA**	**TD**	**LA**	**PF**	**PL**	**NPE**	**FLIQ**
TC	1								
Loans	0.163*	1							
OEA	0.546*	0.280*	1						
TD	0.169*	0.950*	0.285*	1					
LA	0.169*	0.874*	0.297*	0.924*	1				
PF	-0.301*	0.063*	0.060*	0.056*	0.091*	1			
PL	0.306*	-0.008	0.011	-0.018*	-0.045*	-0.490*	1		
NPE	0.042*	-0.091*	-0.299*	-0.058*	-0.015	-0.066*	0.019*	1	
FLIQ	0.026*	-0.066*	-0.010	0.092*	-0.064*	-0.113*	0.052*	-0.045	1
LIQ	-0.013	-0.245*	0.016*	-0.099*	0.178*	0.055*	-0.038*	0.103*	0.047*

tions. Technical change is accounted for by a time trend. Wald test and Likelihood Test support the inclusion of the technical change on the respective restricted and unrestricted model. For the functional form, the study employs Translog function instead of Cobb-Douglas cost function. This is supported by Wald test and Likelihood test.

Table 3.6: Specification Tests for Cost Function.The cost function is used in SFA for measuring efficiency.Wald Test and Likelihood-ratio Test is performed to check the inclusion of the Technical Change and Translog function in SFA.

Hypothesis	**Test**	**Test statistic**	**p-Value**	**Decision**
No Technical Change	Wald Test	3.01	0.003	Rejected
	Likelihood-ratio Test	21.12	0.003	Rejected
No Translog form	Wald Test	55.18	0.000	Rejected
	Likelihood-ratio Test	747.75	0.000	Rejected

In Table 3.7, the signs of all parameters in each model are almost identical indicating a consistent and reasonable result. Most of the coefficients of outputs are significantly negative except. This implies that a 1% increase in Loans would be reducing the total costs by 14.7%. The input prices show a significantly positive effect on total costs. This implies that a 1% increase in price would increase the cost by 34.7%. The coefficient of the quadratic term

for input prices is positive and significant at a 1% level. The results reflect that the higher the price of each input is and the more output is produced, the higher the total costs are. With respect to the time effect, the results show that the total costs in bank operation are increasing year by year, while this effect of rising costs declines gradually.

The main purpose of the study is to investigate the relationship between the bank's cost efficiency and risk. Therefore, the study focuses on how risk measures affect the level and variability of the inefficiency effect. Model 1 of Table 3.7 only regards Funding Liquidity Risk as the determinant of bank efficiency. The results show that Funding Liquidity Risk has a positive effect on the mean and the variance on the inefficiency effect. The results indicate that the bank with a higher Funding Liquidity Risk will have a lower and more varied cost efficiency. A higher Funding Liquidity Risk implies that the bank has a greater possibility that over a specific horizon the bank will become unable to settle obligations with immediacy (Drehmann and Nikolaou, 2013). A higher Funding Liquidity Risk implies that the bank would be facing difficulties to meet its current and future financial obligations because it is unable to get access to the funding. This would be influencing the daily operations of the bank. Market Liquidity and Funding Liquidity Risk have an inverse relationship. The downward spirals between increased market risk and funding liquidity can emerge (Brunnermeier and Pedersen, 2009). This spiral would be starting with a bank, which is short of funding liquidity and has difficulty in getting it from the interbank market. Hence, it would be required to sell the assets. During this period, if the asset market is characterised by frictions. Then, large asset sales would lead to a fall in asset prices. As a result, the banks would be required to post higher margins, which would be increasing the liquidity outflows. For remaining liquid, the banks would be required to sell more assets that would further depress the market prices. The banks would be finding very difficult to roll over the debt. As a result, there would be a possibility of the bank becoming insolvent. Moreover, a higher funding liquidity risk pushes the bank's cost efficiency down and increases the fluctuation of cost efficiency. This was evident in the recent Global Financial Crisis.

Model 2 of Table 3.7 shows the effects of Liquidity Risk on the cost effi-

ciency of the bank. The results show that Liquidity Risk has a significantly positive effect on the inefficiency effect. The level of bank liquidity ratios starts falling when there is an increase in capital and loan activity. This would be exposing the bank to increasing liquidity risk. Without required liquidity and funding to meet the obligations, it would lead to a bank failure. This may lead investors unwilling to lend to the bank and contribute towards the bank failure (Ratnovski, 2013). Furthermore, an increase in Liquidity Risk lowers the profitability of the bank, which pushes down the cost efficiency of the bank and increases the fluctuation of the cost efficiency.

Model 3 of Table 3.7 illustrates the effects of Non-Performing Exposures on the cost efficiency of the bank. It is found that Non-Performing Exposures have a positive effect on the mean and variance of the inefficiency effect. This indicates that a bank with higher Non-Performing Exposures will have a lower and more varied cost efficiency. A bank engaged in risky lending behaviour would be having poor asset quality of the portfolio of the bank. Also, it leads to a decline in the interest income. This behaviour will increase non-performing exposures for the banks. As a result, an increase in Non-Performing Exposures lowers the bank's cost efficiency. These results imply that the banks be focusing on credit risk management which has been proven to be problematic in the past. Serious banking problems have arisen from the failure of the banks to recognise impaired assets and create reserves for writing off these assets.

Model 4 of Table 3.7 estimates the cost function and effects of all risk variables on the inefficiency effect simultaneously. The result is identical to the conclusions of the previous three models. As the size of the bank increases, the bank would be able to hold different portfolio compositions. This would be contributing to an increase in cost efficiency. The capital of the bank is very significant. Capital acts as a buffer against loss, and hence failure with limited liability. Numerous researchers have found that higher capital adequacy will be resulting in smaller tax deduction or lower risk by having a higher proportion of equity to debt (Wang, 2014). By having more capital in place, it would be giving the depositors more confidence in a bank's security and forms a type of internal fund resource. Additionally, it has been seen that the large banks tend to hold capital in excess of the most stringent regulatory requirements as a response to perceived risk exposures and in some instances, with an aim

of maintaining their future profit streams (Chortareas et al., 2011). Loan Activity of the bank influences the cost efficiency of the bank. As there is an increase in loan activity, there would be an enhancement in cost efficiency (Kamarudin et al., 2017). However, there would be lending exposure. Loan quality management is very crucial for the cost efficiency of the bank. Further, credit risk management has been problematic for banks in the past. Banks have found themselves in trouble due to impaired assets and non-performing loans. These prevent the banks from becoming more cost efficient. Additionally, as there is an increase the non-performing exposure especially during the crisis. The banks face liquidity problems especially funding liquidity. This is because the bank would be unable to face its current and future obligations. As a result, the bank faces difficulty in access the funding. This influences the daily operations of the banks. Therefore, the cost efficiency of the banks deteriorates.

To test the endogeneity problem, this study adopts a Durbin-Wu-Hausman test. Funding Liquidity Risk, Liquidity Risk, and Non-Performing Exposures are treated as endogenous. The identification requires at least three instrumental variables, the study selects Deposits, Wholesale Funding, and Non-Performing Assets. These three variables are not weak instruments and do not correlate with total cost (an F-test statistic of joint significance is 1.48, with a p-value of 0.21). The result of Durbin–Wu–Hausman test (F-test statistic is 29.94, with a p-value of 0.00), then, does not indicate that the endogeneity problem is a concern in this study. It is noteworthy that this result does not imply that risk measures are exogenous, only that no statistically significant problem arises from their endogeneity.

Table 3.7: Estimation results for the cost frontier and the determinants of inefficiency.The study specifies four outputs and two input prices. The output variables includes total loans(TL) , Other Earning Assets(OEA), Total Deposits (TD) , and Liquid Assets (LA). Two inputs are price of labour (PL) and price of capital (PC). The total costs (TC) of each sample bank consist of interest expenses and non-interest expenses. Models (1)–(3) reveal the effect of a separate risk category on the inefficiency term, i.e. Funding Liquidity Risk, Liquidity Risk, and Non-Performing Exposures in models (1), (2), (3), respectively. Model (4) reveals the effect of the entire risk category together.The sample consists of 2630 banks in 147 countries for the period 2010-2018. (***, ** and * indicate 1%, 5% and 10% significance levels, respectively.)

Dependent Variable In(TC/PF)	**Model 1**	**Model 2**	**Model 3**	**Model 4**
β_0	5.641***	5.593***	5.285***	5.143***
	(1.01)	(1.012)	1.009)	(1.016)

Table 3.7 – *Continued from previous page*

Dependent Variable In(TC/PF)	**Model 1**	**Model 2**	**Model 3**	**Model 4**
γ	0.083***	0.090***	0.085***	0.089***
	(0.006)	(0.010)	(0.017)	(0.060)
In(TL)	-0.155***	-0.147**	-0.167***	-0.147**
	(0.057)	(0.056)	(0.057)	(0.057)
In(OEA)	-0.281***	-0.277***	-0.288***	-0.27***
	(0.055)	(0.055)	(0.055)	(0.056)
In(TD)	-0.177	-0.206	-0.18	-0.166
	(0.137)	(0.138)	(0.137)	(0.137)
In(LA)	0.147	0.167	0.179	0.187
	(0.159)	(0.16)	(0.159)	(0.16)
$In(PL)^2$	0.361***	0.362***	0.36***	0.347***
	(0.084)	(0.084)	(0.084)	(0.084)
$In(TL)^2$	0.003	0.003	0.004	0.003
	(0.002)	(0.002)	(0.002)	(0.002)
$In(OEA)^2$	0.016***	0.016***	0.018***	0.018***
	(0.001)	(0.001)	(0.001)	(0.001)
$In(TD)^2$	0.001	0.001	0.002	0.000
	(0.004)	(0.004)	(0.004)	(0.004)
$In(LA)^2$	-0.015**	-0.015**	-0.015**	-0.016**
	(0.007)	(0.007)	(0.007)	(0.007)
$In(PL)^2$	0.01***	0.01***	0.01***	0.01***
	(0.003)	(0.003)	(0.003)	(0.003)
In(TL)x In(OEA)	0.006**	0.006	0.006*	0.006**
	(0.003)	(0.003)	(0.003)	(0.003)
In(TL)x In(PL)	-0.001	-0.001	-0.001	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)
In(TL) x In(LA)	0.001	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)
In(TL)xIn(PL)	0.007**	0.007**	0.007**	0.007*
	(0.003)	(0.003)	(0.003)	(0.003)
In(OEA)xIn(TD)	-0.008	-0.006	-0.007	-0.009
	(0.006)	(0.006)	(0.006)	(0.006)
In(OEA)xIn(LA)	0.008	0.006	0.006	0.006
	(0.006)	(0.006)	(0.006)	(0.006)
In(OEA)x In(PL)	0.006**	0.007**	0.006*	0.006*
	(0.003)	(0.003)	(0.003)	(0.003)
In(TD)x In(LA)	0.017*	0.018	0.016*	0.018*
	(0.01)	(0.01)	(0.01)	(0.01)
In(TD)x In(PL)	-0.016**	-0.017**	-0.017**	-0.017**
	(0.008)	(0.008)	(0.008)	(0.008)
In(LA) x In(PL)	0.024***	0.024***	0.024***	0.025***
	(0.008)	(0.008)	(0.008)	(0.008)
Year	0.161***	0.16***	0.157***	0.156***)
	(0.032)	(0.032)	(0.032)	(0.032)
$Year^2$	-0.005***	-0.005***	-0.005***	-0.005***
	(0.001)	(0.001)	(0.001)	(0.001)
Year x In(TL)	0.001	0.001	0.002	0.002
	(0.003)	(0.003)	(0.003)	(0.003)
Year x In(OEA)	-0.008***	-0.008***	-0.007***	-0.007***
	(0.001)	(0.001)	(0.001)	(0.001)

Table 3.7 – *Continued from previous page*

Dependent Variable In(TC/PF)	**Model 1**	**Model 2**	**Model 3**	**Model 4**
Year x In(TD)	0.005	0.005	0.005	0.005
	(0.005)	(0.005)	(0.005)	(0.005)
Year x In(LA)	-0.005	-0.005	-0.005	-0.005
	(0.004)	(0.004)	(0.004)	(0.004)
Year x In(PL)	-0.002	-0.002	-0.002	-0.002
	(0.002)	(0.002)	(0.002)	(0.002)
Effects on μ_{it}				
δ_0	1.328***	1.504***	1.467***	0.797**
	(0.129)	(0.09)	(0.044)	(0.313)
In(TA)				0.021
				(0.018)
FLIQ	0.5***			0.435**
	(0.187)			(0.186)
LIQ		0.005***		0.002
		(0.002)		0.002)
NPE			0.048***	0.049***
			(0.006)	(0.007)
Effects on σ^2_{it}				
γ_0	4.14***	4.275***	4.164***	3.297***
	(0.214)	(0.162)	(0.132)	(0.548)
In(TA)				0.072**
				(0.034)
FLIQ	0.035***			0.035
	(0.284)			(0.26) LIQ
	0.004***		0.004	
		(0.004)		(0.003)
NPE			0.372***	0.377***
			(0.047)	(0.048)
σ_v	-0.785***	-0.785***	-0.782***	-0.782***
	(0.014)	(0.014)	(0.014)	(0.014)
Observations	23670	23670	23670	23670

3.6.3 The Non-Linear Effects of Risk Measures

In this study, the non-monotonic effect of risk measures on the inefficiency effect has been emphasised. Table 3.7 presents the overall effects of risk measures on the level and variability of the inefficiency effect. According to Equations 3.13 and 3.14, the marginal effects on the mean and variance of the inefficiency effect can be calculated. The study sort and classify the samples into five groups based on quantiles by each criteria variable. The criteria variables used in the study are Funding Liquidity Risk, Liquidity Risk, and Non-Performing Exposures. This is following by comparing the average cost efficiency and the marginal effects on E(μ_{it}) and V(μ_{it}) across the groups (the lowest, middle, and highest groups).

The study performs the test for monotonicity using the Spearman Rank Order correlation. Spearman's correlation measures the strength and direction of monotonic association between two variables. If spearman correlation coefficient of a variable is close to 0, it means there is no monotonic relationship between variables. Table 3.8 presents the Spearman's correlation coefficients for the risk measures variable with the efficiency. The results shows a very weak correlation. This indicates that the monotonic relationship is very weak. Therefore, the study looks into the non-monotonicity effects.

Table 3.8: Spearman's correlation coefficients for the risk measures variable with the efficiency.Risk Measures are Funding Liquidity Risk, Liquidity Risk and Non-Performing Exposures.Efficiency scores are calculated using SFA.The sample period is 2005-2019.The sample consists of 1931 banks.(***, ** and * indicate 1%, 5% and 10% significance levels, respectively.)

Risk Variables	**Efficiency**
FUNDING LIQUIDITY RISK	-0.003***
LIQUIDITY RISK	0.095***
NON-PERFORMING EXPOSURES	-0.080***

Table 3.9 presents the calculation results of Cost Efficiency and Marginal Effects by various sorted criteria variables using Bootstrapping with 1000 replications. For the criteria variables, the marginal effects on E(μ_{it}) and V(μ_{it}) measures how an increase in the criteria variable changes the mean and variance of the inefficiency effect. The average marginal effect on E [μ_{it}] in the first Funding Liquidity Risk quantile is 0.438. Since $\frac{\vartheta E[In\ TC_{it}]}{\vartheta FLIQ_{it}} = \frac{\vartheta E[\mu_{it}]}{\vartheta FLIQ_{it}}$, this means an increase in Funding Liquidity Risk leads to inefficiency increase and an increase in Total Costs by 43.8%. This figure is statistically significant. Table 3.9 does not represent non-monotonic effects, but rather non-linear effects of some risk factors on the mean and variance of the inefficiency effect. This is because there is the same marginal effects across different group sorted by criteria variables affect efficiency non-linearly in the sample. The marginal effects in regard to the variance of the inefficiency effect are measured by V[μ_{it}] in Table 3.9. For the banks in the lowest group (1st quantile) by Funding Liquidity Risk, the bank's cost efficiency becomes more variable if the levels of Funding Liquidity Risk increases. In other words, an increase in Funding Liquidity Risk increases the variation in Cost Efficiency by 16.5%. Combining

the marginal effects on E[μ_{it}] and V[μ_{it}] , other things being equal, a bank in the lowest group would have lower and more variable cost efficiency. The results for Non-Performing Exposures are similar to Funding Liquidity Risk.

For Liquidity Risk, the results indicate that marginal effects on E[μ_{it}] and V[μ_{it}] are non-monotonic because the signs are different across the groups. For the lowest group (1st quantile), the average marginal effect on the mean of the inefficiency is 6.96. For the highest group (5th quantile), it is -0.004. This means that in the lowest group, an increase in Liquidity Risk increases the inefficiency by 69.6% whereas, in the highest group, an increase in the Liquidity Risk decreases the inefficiency by 4%. The average marginal effect on the variance of the inefficiency in the lowest group and highest group are -0.001 and 0.239. Together with the results on the marginal effects on the mean of the inefficiency, the lowest group is likely to have higher cost inefficiency and more stability in the cost efficiency whereas the highest group will have lower cost inefficiency and more variable cost efficiency.

In this study, the time trends of cost efficiency and average marginal effects on E(μ_{it}) and V(μ_{it}) over the sample period has been investigated. The risk variables are selected if their overall effect is significant according to Table 3.7 and then compared with the average marginal effects over years. Table 3.10 shows that average cost efficiency of the banks globally improved from 35.0% in 2010 to 35.7% in 2012. This shows that the banks were gradually improving the cost efficiency following the global financial crisis. However, the average cost starts to deteriorate after 2012 until 2015. This is due to scheduled introduction of the new regulations such as Basel III. From 2017 onwards, the cost efficiency has improved and reached 38.8% in 2018. The results of the marginal effects of the risk measures over the year in Table 3.10 indicate that the effects of the risk measures are not consistent over time. For Funding Liquidity Risk , the marginal effect on E(μ_{it}) was very high in the year 2011. After 2011, the effect starts declining until 2016. However, from 2017 onwards, the effect has again started increasing. The marginal effect shows the negative effect on the cost efficiency. The marginal effect on V(μ_{it}) shows the variability in the cost efficiency was high in 2012 before the variability started declining. It reached its lowest in 2014. After 2014, the marginal effect on V(μ_{it}) has been rising. The marginal effect on V(μ_{it}) has both negative

Table 3.9: Cost Efficiency and marginal effects by various sorted criteria. Cost Efficiency scores are calculated using SFA.The study sort and classify the samples into five groups based on quantiles by each criteria variable. The criteria variables used in the study are Funding Liquidity Risk, Liquidity Risk and Non-Performing Exposures. This is followed by comparing the average cost efficiency and the marginal effects on E(μ_{it}) and V(μ_{it}) across the groups (the lowest, middle, and highest groups). (***, ** and * indicate 1%, 5% and 10% significance levels, respectively.)

Quintile	**Mean of Variables**	**Avg. Cost Efficiency**	**Marginal Effects on E[μ_{it}]**	**Marginal Effect on V[μ_{it}]**
By Funding Liquidity Risk				
1	0.324	0.330	0.438***	0.165***
3	0.705	0.360	0.273***	2.486***
5	0.886	0.364	0.696***	0.657***
By Liquidity Risk				
1	11.948	0.354	6.268***	-0.001***
3	29.624	0.336	1.751***	0.072***
5	62.005	0.365	-0.004***	2.394***
By Non-Performing Exposures				
1	0.419	0.419	0.569***	0.695***
3	0.361	0.361	0.411***	0.749***
5	3.848	0.263	0.051***	1.355***

and positive effect on the cost efficiency over the years. However, from 2017 onwards, the marginal effect has a positive effect on the cost efficiency. For Liquidity Risk , the marginal effect on E(μ_{it}) was very high in the year 2010. In the following years, the effect started declining and reaching its lowest in 2013. However, from 2014 onwards the effect started increasing. The marginal effect of Liquidity Risk on E(μ_{it}) is U shape like pattern. After 2014, the increase in the marginal effect indicates the negative effect on the cost efficiency. Similarly, The marginal effect of Liquidity Risk on V(μ_{it}) has a negative effect on the cost efficiency.For Non-Performing Exposures, The marginal effect on E(μ_{it}) has a positive effect on the cost efficiency.This means that when the marginal effect on E(μ_{it}) increases , the cost efficiency declines and vice versa. However, the marginal effects on V(μ_{it}) show inverse U shape like pattern.This might mean that this effect weakens over the sample period though they still significantly and negatively affect the cost efficiency.

3.6.4 Cost Efficiency Across regions

The study aims to provide a comprehensive view of how the risk measures affects the cost efficiency of the banks across different regions. Basel I was formed to create harmonisation of regulatory and capital adequacy standards only within the member states of the Basel Committee. All the states of the G-10 are considered developed markets by most international organisations.Therefore, the regulations were tailored for banks operating in developed markets.However, the banks operating in emerging markets adopted Basel I requirements.This created a false sense of security within an emerging economy's financial sector while creating new, less obvious risks for its banks (Balin, 2008).Therefore, it is important for conduct a comprehensive analysis of how the risk measures such NPEs affect the cost efficiency of the banks across different regions.By doing so, the regulators would be able to get a detailed analysis of how it impacts the efficiency of the banks.Furthermore, it will allow the regulators and authorities to form effective regulations which would help in preventing excessive risk taking by the banks.Additionally, by examining the marginal effects of risk measures across different regions will provide more detailed facts about how these risk measures influence both the level and variability of the inefficiency effect across regions.

Table 3.10: Cost Efficiency and the average marginal effects on E(μ_{it}) and V(μ_{it})over the 2010-2018 period. According to the estimation result of Table 3.7 , Risk Measures variables are selected if their effects are significant. (***, ** and * indicate 1%, 5% and 10% significance levels, respectively.)

	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Average Cost Efficiency	0.351	0.355	0.358	0.354	0.352	0.348	0.347	0.351	0.398
Average Marginal Effect on E(μ_{it})									
Funding Liquidity Risk	17.988***	50.927**	43.7**	29.563**	29.19***	15.224**	11.615**	15.752**	15.273**
Liquidity Risk	39.655**	37.483**	37.163**	23.024***	37.648**	36.086**	35.728***	33.81***	31.896***
Non-Performing Exposures	53.468**	48.422***	41.196**	27.057**	38.419**	37.775***	34.706**	32.464***	39.519***
Average Marginal Effect on V(μ_{it})									
Funding Liquidity Risk	20.204***	33.241*	35.005**	26.833**	10.819**	14.509**	17.186***	39.183***	46.813***
Liquidity Risk	13.666**	33.61***	28.465**	60.292**	42.802**	27.971**	10.648**	32.642**	39.519***
Non-Performing Exposures	17.699**	26.851**	32.495**	24.326**	18.314**	12.004***	14.681**	36.676**	27.281***

Table 3.11: Descriptive statistics of Cost Efficiency for different regions.Cost Efficiency scores are calculated using SFA.The sample period is 2010-2018.The sample consists of 2630 banks in 6 different regions.Reported statistics are mean, standard deviation, minimum and maximum.

Region	Mean	Std. Dev.	Min	Max
Africa	0.296	0.191	0.000	0.740
Asia-Pacific	0.341	0.184	0.000	0.771
Europe	0.369	0.186	0.000	0.819
Latin America and Caribbean	0.300	0.190	0.001	0.833
Middle East	0.360	0.190	0.000	0.730
United States and Canada	0.344	0.204	0.001	0.791
Total	0.353	0.189	0.000	0.833

Table 3.11 presents the descriptive statistics of Cost Efficiency for the different regions over the sample period 2010-2018. The global average Cost Efficiency is .353. At the global level, the banks could reduce input costs by approximately 64.7% by using their inputs more efficiently at a given level of output. Over the sample period, the most cost-efficient banks are in Europe. The average cost efficiency of Europe is .369, which is higher than the global average cost efficiency. The banks are in Europe could reduce input costs by approximately 63.1% by using their inputs more efficiently at a given level of output. The banks in Europe can generate more output from their inputs. Furthermore, In Europe, banks have efficient management in their total costs. There is no bank in the sample, which is fully cost, efficient. The banks in Africa are found to be the least cost efficient with mean cost efficiency is .296. This implies that on average banks in Africa could reduce input costs by approximately 70.4% by using its inputs more efficiently at a given level of output. The difference between the average cost efficiency in Africa and global cost efficiency might be because the banks in Africa have problems in generating outputs more cost-efficiently. This could be explained by the loans generated in Africa is the lowest. Loans generated is lower than deposits. Also, it could be interpreted that the banks in Africa have more difficulties compared to banks in other regions to have efficient management in their total cost. Latin America and the Caribbean region's average cost efficiency is near the average cost efficiency of Africa. This reflects the problem in the banking sector in Latin America and the Caribbean region over the sample period. The

average Cost Efficiency of Asia-Pacific and the United States and Canada are close to each other. Only Europe and Middle East's average cost efficiency is higher than the global cost efficiency.

The study compares the trend pattern of each region's cost efficiency and examines whether the marginal effects of risk measures differ across regions. Figure 3.1 presents the average cost efficiency of the banks over time. The changes in the average cost efficiency could be explained by the changes in the outputs and input prices over the years. From 2012, the average cost efficiency has been decreasing. It reaches the lowest point in 2017. This is lower than the average cost efficiency in 2010. Loans and Price of labour increased while Other Earning Assets and Price of Deposits decreased. Also, Total Costs have increased over this period. This reflects that the banks were not efficient in managing their total costs. As a result, the cost efficiency was declining. However, only in 2018, Cost Efficiency has increased. In 2018, the outputs and input prices are increasing and decreasing. In addition, Total Costs have increased every year. Nevertheless, banks have become more efficient in managing their total costs. Therefore, the banks have become more cost efficient and improved their cost efficiency.

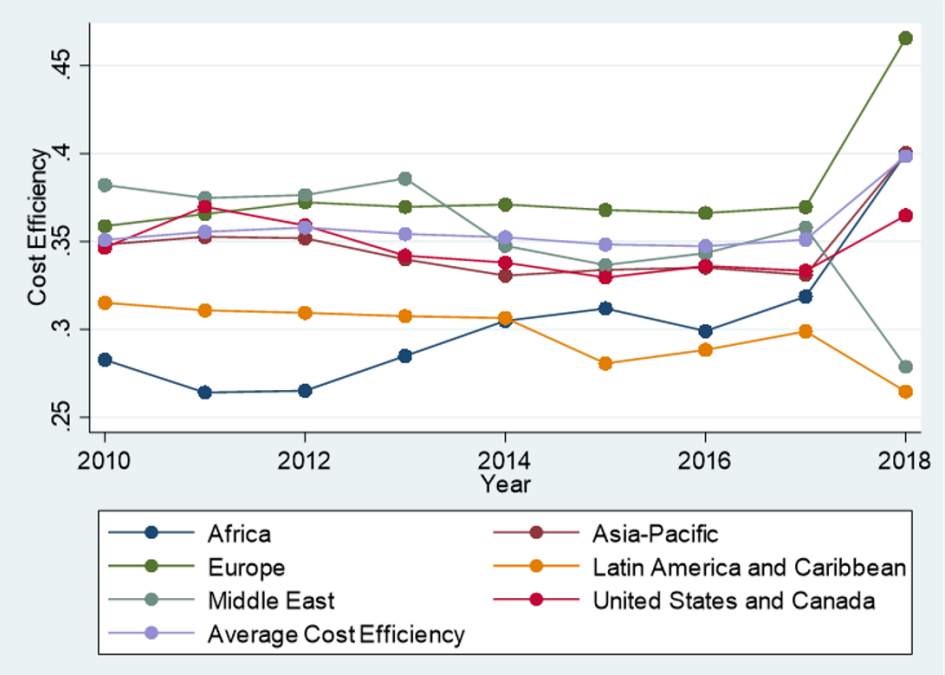
The Cost Efficiency of Africa and Latin America and Caribbean have been lower than in other regions over time. Since 2012, the Cost Efficiency of Africa has been improving over time. But in 2016, there has been a decrease in the Cost Efficiency of Africa. This is due to the continental problems, which led to some of the global banks to leave the continent. The continental problems are the opportunities for more growth in the region diminished and the near future signs were not promising. Furthermore, the unemployment figures suggested that there are not enough jobs being created for the people to start opening up bank accounts. Cost Efficiency in Latin America and the Caribbean region has been decreasing over the years. Brazil has been one of the major economies of Latin America. Brazil suffered from a severe economic crisis from 2014 till 2016. The growth in Brazil slowed significantly in 2014, which was followed by a drop in growth for two consecutive years. Furthermore, the Crisis in Venezuela contributed to a decrease in cost efficiency. This crisis was a result of political corruption and the country started facing cash shortages. The country experienced hyperinflation. These domestic financial

vulnerabilities ten to amplify the adverse impact of severe turbulence episodes in international financial markets. The average cost efficiency in the United States and Canada has been declining since 2011. This is due to the banks struggling to recover from the financial crisis. The regulators have issued new regulations. These regulations forced the banks to fund their operations with less debt and more equity has proved to be problematic for the banks. Over the years, the cost efficiency in the Middle East has deteriorated. Political issues such as the Arab Spring have contributed to this deterioration in cost efficiency. Additionally, the high population growth and low productivity, and high trade restrictiveness have led to this deterioration. Global cost Efficiency has been decreasing until 2018. The events across the different regions have contributed to this decline in efficiency. However, in 2018, the global cost efficiency has increased along with most of the regions witnessing an increase in efficiency. This could be because the banks have become familiar with the new regulations and the economic environment in which they are operating has become more stable.Moreover, the banks have recovered from the financial difficulties of the crisis. It reveals that such financial crisis makes the recovery period for the banks longer.Additionally, it takes time for the banks to improve their efficiency.

This study compares the marginal effects on $E(\mu_{it})$ and $V(\mu_{it})$ among the sorted criteria in each region.The marginal effects provide a detailed view of how the cost efficiency is affected by the risk measures across different regions.Furthermore,the study examines whether marginal effects differ across regions.

The study sort and classify the samples into five groups based on quantiles by each criteria variable. The criteria variables used in the study are Funding Liquidity Risk, Liquidity Risk and Non-Performing Exposures. This is followed by comparing the average cost efficiency and the marginal effects on $E(\mu_{it})$ and $V(\mu_{it})$ across the groups (the lowest, middle, and highest groups). Table 3.12 gives the calculation results of Cost Efficiency and Marginal Effects by various sorted criteria variables across different regions using Bootstrapping with 1000 replications. For Funding Liquidity Risk, the marginal effects on $E(\mu_{it})$ on the banks of Asia-Pacific , Latin America and Caribbean , Middle East ,and United States and Canada show a non-monotonic pattern. This

Figure 3.1: Average Cost Efficiency of the different regions from 2010-2018.Cost Efficiency scores are calculated using SFA.The sample period is 2010-2018.The sample consists of 2630 banks in 6 different regions.Reported is the average cost efficiency over time in 6 different regions.



means that in these regions, there is a negative inefficiency effect in the lowest group. But, the effect turns to positive inefficiency effect in the middle and highest group. This suggests the behaviour the banks and how they banks with different risk levels operate.As the bank with the lowest funding liquidity risk in Middle East will becoming more cost inefficient.While the bank with highest funding liquidity risk in same region becoming more cost efficient.This provides a detailed evidence of how the funding liquidity risk affects the cost efficiency of the bank differently among the banks based in same region. For Africa and Europe , the marginal effects shows a linear effect and have a positive inefficiency effect across all the groups. The marginal effects on V(μ_{it}) for Latin America , Middle East and United States and Canada reveal a non-monotonic pattern. In these regions , the banks in the lowest group have a negative variability in the lowest group and turns positive in the middle and highest groups. The banks in Africa have the highest variability. This means the cost efficiency is more varied in this region.

For Liquidity Risk , The marginal effects on E(μ_{it}) in Europe shows a non-monotonic pattern. It shows a negative inefficiency effect on the low and middle groups whereas a positive inefficiency effect on the highest group. In Africa,

the marginal effects on E(μ_{it}) across all the groups shows a positive inefficiency effect. The results reveal how the banks operate differently in different regions. The liquidity risk has different influence across different groups in different regions.This can lead to damaging effects on the economy because the certain banks will engage themselves in high liquidity risk in order to improve their cost efficiency. However, this trade-off between liquidity risk and cost efficiency could prove lethal for the sector. For Europe, the marginal effects on V(μ_{it}) across on the groups is positive and shows a monotonic effect. Asia –Pacific , Latin America and United States and Canada shows the marginal effects on V(μ_{it}) across the groups to be negative. The marginal effects on V(μ_{it}) across all the groups in Africa reveal a non-monotonic pattern. The banks in middle and highest groups in Europe have the highest variability. This reveals that the cost efficiency is more varied among the banks in Europe.

For Non-Performing Exposures, marginal effects on E(μ_{it}) across all the regions reveals a positive inefficiency effect. This shows a positive monotonic effect. On average across the groups, Latin America and Caribbean has the highest positive inefficiency impact. The marginal effects on V(μ_{it}) is similar to the marginal effects on E(μ_{it}). The marginal effects on V(μ_{it}) increases as we move along the groups. The lowest group has the lowest variability , this increases as we move to middle and highest groups.These results reveal the significance of NPEs.It provides a detailed analysis why having a harmonised measure for credit risk is important.Furthermore, it reveals that this new definition has same effect across different groups in different regions.As a result, it ensures all the banks will be taking this risk measure seriously.

The marginal effects provides a comprehensive analysis of the risk measures on the cost efficiency of the banks across different regions.The results reveal that the different risk measures have different effect on the cost efficiency across different groups across different regions.It is significant to take into consideration how the banks operations when formulating a policy.By taking it into the consideration, the policymakers and regulators will be able to ensure the policies made by them is meeting the target.Moreover,it will ensure the financial stability in the country.

Table 3.12: Cost Efficiency and marginal effects by various sorted criteria among the different regions.Cost Efficiency scores are calculated using SFA.The sample period is 2010-2018.The sample consists of 2630 banks in 6 different regions.The study sort and classify the samples into five groups based on quantiles by each criteria variable. The criteria variables used in the study are Funding Liquidity Risk, Liquidity Risk and Non-Performing Exposures. This is followed by comparing the average cost efficiency and the marginal effects on E(μ_{it}) and V(μ_{it}) across the groups (the lowest, middle, and highest groups). (***, ** and * indicate 1%, 5% and 10% significance levels, respectively.)

	Africa	Asia-Pacific	Europe	Latin America and Caribbean	Middle East	United States and Canada
Marginal Effect on E[μ_{it}]						
Funding Liquidity Risk						
Low	0.296**	-1.235**	0.928**	-1.313**	-0.964**	-1.372**
Middle	0.332**	0.424**	0.199**	0.172**	0.394**	0.317**
High	0.544***	0.806***	0.12***	0.693***	0.712***	0.535***
Liquidity Risk						
Low	0.005**	-0.003**	-0.004***	-0.006**	-0.002***	-0.002**
Middle	0.307**	-0.002**	-0.002***	-0.003**	-0.002**	-0.002***
High	0.329**	-0.002**	0.017***	-0.003***	-0.004***	-0.001**
Non-Performing Exposures						
Low	0.427**	0.408***	0.432***	0.451**	0.415**	0.376**
Middle	0.395**	0.392***	0.43***	0.413***	0.397**	0.382**
High	0.229***	0.504***	0.372***	0.619**	0.453***	0.416***
Marginal Effect on E[ν_{it}]						
Funding Liquidity Risk						
Low	16.325**	5.982**	0.81***	-0.321**	-0.166**	-0.81***
Middle	12.352***	1.598***	1.778***	1.267***	1.39**	1.217***
High	11.598***	2.432***	1.79***	1.97***	2.127**	1.57***
Liquidity Risk						
Low	-0.005**	-0.003**	0.000***	-0.005**	-0.003**	-0.003***
Middle	1.27***	-0.002**	3.026**	-0.003**	-0.002***	-0.002**
High	1.368**	-0.001***	3.924***	-0.003**	0.004**	-0.002***
Non-Performing Exposures						
Low	0.654**	0.74***	0.682***	0.703**	0.698**	0.697***
Middle	0.693***	0.796**	0.724***	0.739***	0.776**	0.74***
High	0.865***	1.682**	1.72***	1.253***	0.839**	0.843***

3.6.5 Robustness Checks on Cost Efficiency Estimates

In this section, the study compares SFA-efficiency results with efficiency outcomes using the Thick Frontier Approach (TFA) and the Distribution Free Approach (DFA). TFA uses the same functional form for the frontier cost function as SFA but is based on a regression which is estimated using only the ostensibly best performers in the data set—those in the lowest average-cost quartile for their size class. DFA specifies a functional form for the cost function, as does SFA and TFA, but DFA separates inefficiencies from random error in a different way. It does not impose a specific shape on the distribution of efficiency, as does SFA, neither does it impose that deviations within one group of firms are all random error and deviations between groups are all in-

efficiencies, as does TFA. Instead, DFA assumes that there is a core efficiency or average efficiency for each firm, which is constant over time, while random error tends to average out over time. Bauer et al. (1998) found that SFA, TFA, and DFA parametric approaches tended to yield about the same distributions of efficiency, rank banks in roughly the same order, and identify mostly the same banks as best-practice and worst-practice. Following Bauer et al. (1998) and Rossi et al. (2009), this study compares the SFA efficiency scores with TFA and DFA which will allow us to assess the robustness of efficiency scores obtained using SFA.

Tables 3.13 and 3.14 shows the robustness results of SFA results by comparing them to efficiency scores using TFA comparing them to efficiency scores using TFA and DFA as well as to standard non-frontier measures of performance, such as banks‘ ROA, their cost ratio or their cost/income ratio. The results of these consistency checks support our efficiency estimates by means of Spearman rank correlations. Firstly, the study compares the efficiency scores obtained from SFA with TFA and DFA. The results show the efficiency scores obtained from SFA are highly significant positive rank correlations with the TFA and DFA.

Table 3.13: The robustness checks for cost efficiency with different techniques. Spearman Rank correlations between efficiency results obtained using SFA ,DFA and TFA. (***, ** and * indicate 1%, 5% and 10% significance levels, respectively.)

	SFA	**DFA**	**TFA**
SFA	1		
DFA	0.8157***	1	
TFA	0.5592***	0.5972***	1

The study compares the SFA efficiency scores with non-frontier measures of performance. The standard performance measures are returns on asset, cost ratio, and cost-to-income ratio. Cost Ratio is defined as the ratio of total costs to total assets. The bank managers and consultants to assess their performance and rank themselves against their peers within the industry (Bauer et al., 1998) use these measures. These performance measures are indicators of economic optimization in terms of bank costs and revenues. The positive rank order correlation with ROA and negative rank order correlation with cost ratio and cost-to-income ratio. This would give assurance that the frontier measures

are not simply artificial products of the assumptions made regarding the underlying optimization concept, the shape of the efficient frontier, the existence of random error, and any distributional assumptions imposed on the inefficiencies and random error. The results presented in Table 14 show that cost efficiency scores are significantly correlated with non-frontier measures with the expected signs.

Table 3.14: The robustness checks for cost efficiency with standard performance measures using Spearman Rank correlations. Cost Efficiency is obtained using SFA. Cost Ratio = total cost/total assets. . (***, ** and * indicate 1%, 5% and 10% significance levels, respectively.)

	Return on Assets	**Cost-to-Income Ratio**	**Cost Ratio**
Cost Efficiency	0.135***	-0.156***	-0.165***

3.7 Conclusion

This study explores the role of risk measures such as Funding Liquidity Risk, Liquidity Risk, and NPEs in determining the cost efficiency of the banks. In this study, the heteroscedastic stochastic frontier model is used for the estimation. This allows us to find the effect of each risk measure on the mean and variance of the cost efficiency. Additionally, it allows us to provide a comprehensive analysis of the effects of risk measures on the cost efficiency of the banks.

The results show that each risk measure presents a similar effect on the cost efficiency of the banks. Funding Liquidity Risk has a positive effect on the mean and the variance on the inefficiency effect. This means a bank with a higher Funding Liquidity Risk will have a lower and more varied cost efficiency. Liquidity Risk has a significantly positive effect on the inefficiency effect. This indicates that an increase in Liquidity Risk lowers the profitability of the bank, which pushes down the cost efficiency of the bank and increases the fluctuation of the cost efficiency. Additionally, NPEs have a significantly positive effect on the mean and variance of the inefficiency effect.

The study looked into the marginal effects of the risk measures on the mean and variance for a detailed analysis. The results indicate that there are non-linear effects of some of the risk factors such as Funding Liquidity Risk and NPEs on the mean and variance of the inefficiency effect. However, for

Liquidity Risk, the marginal effects indicate a non-monotonic effect.

The study investigates the effects of the risk measures on the mean and variability of the inefficiency effect over time. The results reveal that the effects of the risk measures are not consistent over time. In 2011, the marginal effect of Funding Liquidity Risk on the mean is very high. After 2011, the effect starts declining until 2016. However, from 2017 onwards, the effect has again started increasing. The marginal effect shows the negative effect on cost efficiency. The marginal effect on variance has both a negative and positive effect on cost efficiency over the years. For Non-Performing Exposures, The marginal effect on mean has a positive effect on the cost efficiency and the marginal effect on variance shows inverse U-shape like pattern. For Liquidity Risk, the marginal effect on mean shows U-shape pattern and on variance has a negative effect on the cost efficiency.

The comparison of the trend pattern of each region's cost efficiency reveals that the Cost Efficiency of Africa and Latin America and Caribbean have been lower than in other regions over time. From 2011, the average cost efficiency in the United States and Canada. Over the years, the cost efficiency in the Middle East has deteriorated. Global cost Efficiency has been decreasing until 2018. The events across the different regions have contributed towards this decline in efficiency. However, in 2018, the global cost efficiency has increased along with most of the regions witnessing an increase in efficiency.

In this study, the marginal effects of how these risk measures affect both the level and variability of the inefficiency effect across the regions have been investigated. For Funding Liquidity Risk, the marginal effects on the mean of the inefficiency effect of the banks in Asia-Pacific, Latin America and the Caribbean , Middle East, and the United States and Canada show a non-monotonic pattern. The marginal effects on variability of the inefficiency effect for Latin America, the Middle East, and the United States and Canada reveal a non-monotonic pattern. In these regions, the banks in the lowest group have a negative variability in the lowest group and turn positive in the middle and highest groups. For Liquidity Risk, The marginal effects on the mean in Europe show a non-monotonic pattern. It shows a negative inefficiency effect on the low and middle groups whereas a positive inefficiency effect on the highest group. The marginal effects on the variability across on the groups in

Europe is positive and shows a monotonic effect. This reveals that the cost efficiency is more varied among the banks in Europe. For Non-Performing Exposures, marginal effects on the mean of the inefficiency effect across all the regions reveals a positive inefficiency effect. On average across the groups, Latin America and Caribbean has the highest positive inefficiency impact. The marginal effects on variability on the inefficiency effect increases as we move along the groups. The lowest group has the lowest variability, this increase as we move to middle and highest groups.

The study provides an in-depth analysis of the risk measures.The recent crisis showed how having inconsistent international standards for categorising problem loans and funding liquidity proved to be a major problem for the banks.The investigation will be useful for the regulators and policymakers.As an increase in funding liquidity risk in a region impacts on the cost of the efficiency of the bank.Furthermore,NPEs which provides consistent international standards for categorising problem loans impacts on the cost efficiency.The results will be useful for the regulators and policymakers.The results will help in shaping new regulations which will be preventing the bank from excessive risk-taking.Additionally,the results show how the changes in the risk measures impacts the cost efficiency.

Chapter 4

The role of Cross-Border Exposures and Liquidity Shock on Technical Efficiency of the banks.

4.1 Introduction

Banks take a central role in cross-border capital flows. In most countries around the world, banks acquire foreign assets in addition to domestic assets. These foreign assets include loans to foreign entities and holdings of foreign bonds and other instruments. Equally, on the liability side, banks raise external funding. Such foreign liabilities include deposits of non-residents and the sale of bonds and other securities to foreign investors. With the continuing move towards financial integration, cross-border banking has gained increasing attention in the academic literature over the last decade. Cross- Border banking may not only influence individual banks but may have wider consequences for the economy and the financial system. The wider benefits from cross-border banking may, among others, arise from non-financial firms being more resilient against domestic crises via access to credit from non-local banks (Keeton et al., 2009), or from more efficient banking sectors through increased competition from foreign banks (Schoenmaker and Wagner, 2013).

The market liquidity failures intensified the Global Financial Crisis. The financial institutions had to manage their balance sheets in response to mea-

sured risk and price changes. This translated to cross-border banking. During the crisis, the banks decreased their local lending and their cross-border lending ((Takáts, 2010) and (Herrmann and Mihaljek, 2013). De Haas et al. (2011) found that the reduction in cross-border lending is limited for the banks which are geographically closer to the borrower and have a local office or strong relations with the local banks. The effects on the cross border lending depend on the interaction of borrower's demand and lender's supply. Numerous researchers found that it is likely the cross-border lending increases are permanent after banks and customers have invested in overcoming informational imperfections.

During the Global Financial Crisis, the aggregate liquidity shock is associated with the increasing volatility of asset prices with aggravated concerns over counterparty risk, liquidity risk and market conditions. This resulted in disruptions in the interbank market(Gorton and Metrick, 2012). Additionally, this affected not only the funding costs of banks but also bank lending (Allen et al., 2011). Using data from the US interbank market,Afonso et al. (2014) show that borrowers pay lower prices and borrow more from their concentrated lenders and that—when there are exogenous shocks to liquidity supply—concentrated lenders insulate borrowers from the shocks without charging significantly higher interest rates. Bräuning and Fecht (2017) evaluates the effects of lending relationships on the price and availability of liquidity in the German interbank market. They found that, during the crisis, relationship lenders provided cheaper loans to their closest borrowers, confirming that lending relationships help banks to reduce search frictions, even for opaque borrowers.

This study investigates the impact of cross-border banking, i.e., geographical diversification, on individual banks with liquidity shock in relation to the financial development of the home country. Generally, diversification has the potential to reduce risk (Markowitz, 1959). There are opposite views on whether geographical diversification is beneficial for banks.Levy and Sarnat (1970) found that geographical diversification could generate positive effects, as there is a non-perfect correlation across country-specific risks. Therefore, resulting in risk reduction in an internationally diversified portfolio. However,Winton (1999) argues that geographical diversification is not always ben-

eficial. For example, when banks have loans with high downside risks or when banks expand into sectors where they have little expertise. In addition, the further a bank away from its home country, the more difficult it may be to manage.

Financial development increases a country's resilience and boosts economic growth, but trade-offs between growth, and stability can emerge. Financial development has numerous benefits such as it mobilizes savings, promotes greater information sharing, improves resource allocation, and facilitates diversification and management of risk. However, there are costs as well, particularly at high levels of financial development. In fact, there can be instances where there is "too much finance"— that is, instances where the costs outweigh the benefits of financial development. The diversity of financial systems across countries implies that one needs to look at multiple indicators to measure financial development. As a result, the study employs a more comprehensive financial development indicator developed by Svirydzenka (2016). This allows us to investigate the role of countries with similar financial development have on cross-border banking with liquidity shock on the efficiency of the banks. As the Global Financial Crisis, raised questions about what went wrong and how the changes in the cross-border banking played a part in deepening this crisis.

The study attempts to fill the gap by providing evidence on the role of cross-border banking with liquidity shock on the efficiency of the banks in relation to the financial development of the home country. To do so, the study conducts an analysis of the impact of the cross border banking with liquidity shock on the efficiency scores estimated by Weighted Russell Directional Distance Model by using sub-samples based on the financial development of the home country. The study uses the balance sheet data of the banks, macroeconomic conditions, cross-border exposures, and liquidity shock to investigate the impact on bank efficiency. To my knowledge, this is the first study to do. The study uses a sample of 1931 banks in 15 countries in Europe. The study employs a Financial Development indicator to divide the sample into 2 sub-sample. With sub-sample with high financial development has 1229 banks in 8 European countries and with lower financial development have 702 banks in 7 European countries.

The results indicate that the average technical efficiency of the banks in

the country with high financial development is 0.19. The average bank in the sample could improve its technical efficiency by 81%. The average technical efficiency of the banks in the country with low financial development is 0.183. The average bank in the sample could improve its technical efficiency by 81.7%. The financial development difference between the two sub-samples is 0.054. However, the major difference appears by looking at individual countries in the two sub-samples. The most financially developed country in the sample was Germany could improve its technical efficiency by 80.8%. The least financially developed country in the sample was Spain. The average technical efficiency of the banks in Spain is 0.230. This means that it could improve its technical efficiency by 77%. The average technical efficiency of the banks in Spain witnessed many fluctuations. On average, the technical efficiency of the banks declined after the Global Financial Crisis. The changes in the technical efficiency of the banks facing liquidity shocks are more unstable. The technical efficiency of the banks facing Liquidity Shocks is much lower during the Global Financial Crisis. The technical efficiency of the banks not facing liquidity shock is more similar to the average technical efficiency of the banks. The decline in the cross-border exposures was a witness with a decline in efficiency. But, the decline was minimum in the domestic exposures. This reflects the significance of the cross-border exposures on the efficiency of the banks.

Following this, the Honore's Tobit Estimator results provide evidence of the cross-border exposures with liquidity shock on the efficiency of the banks in relation to the financial development of the home country. In countries with high financial development, both domestic exposures and foreign exposures have a significant impact on the technical efficiency of the banks. The case is different for the banks located in countries with less financial development. In those countries, only foreign exposures are having a significant impact. The results reflect the different banking practices in relation to the financial development of the home country. With high financial development, the bank can diversify better. However, with low financial development, the bank is looking to get better returns by investing in foreign countries. When controlling for domestic exposures and exposures from different regions, the results indicate that the exposures from different regions are highly significant. For countries with high financial development, Domestic Exposures, Europe Exposures, and

North America Exposures have a significantly positive relation with technical efficiency. South America, Africa, and Asia Exposures have a significantly negative relation with technical efficiency. For countries with lower financial development, Domestic Exposures, South America Exposures, Africa Exposures, and Asia Exposures have a significantly positive relation with technical efficiency. The results indicate that banks are more likely to invest in countries with similar levels of financial development. By investing in such countries, the bank can improve its technical efficiency. However, in countries with high financial development, the banks improve efficiency by reducing exposures from countries with lower financial development. The results indicate that the role of financial development and cross-border exposures play in the efficiency of the banks.

The rest of the study is structured as follows. Section 4.2 provides an overview of the Cross Border Banking, Cross-Border banking during the financial crisis, Determinants of cross border positions, and Cross-border banking and liquidity. Section 4.3 outlines Weighted Russell Directional Distance Model while Section 4.4 presents the sample and variables used in the study. Section 4.5 discuss the results and Section 4.6 concludes the study.

4.2 Literature Review

4.2.1 Cross-Border Banking

According to the Bank of International Settlements (BIS, 2011a), "direct cross-border ("offshore") lending to non-banks and the cross-border component channelled by resident banks – become more important. That is, during booms these two international components tend to grow faster than the credit granted by banks located in the country." The term cross-border banking is used for both banks and banking customers going abroad. Cross-border banking has a significant role to play on financial stability. The recent crisis highlighted the role of cross-border banking played in intensifying the crisis. This led to an increase in attention towards cross-border banking. Cross-border banking has both benefits and costs.

A major benefit of cross-border banking is due to the potential for risk diversification (Markowitz, 1959). This allows the assets of cross-border banks

to be less sensitive to country-specific shocks and the probability of collapse. A bank becomes less exposed to a domestic or foreign shock by spreading its activities across different countries. This helps to reduce lending volatility. Cross-border banking facilitates international risk sharing.

With financial liberalisation and integration, domestic investors can diversify their asset portfolios internationally by holding assets issued by firms and financial institutions around the world in addition to domestic ones. Therefore, they become less exposed to localised shock. This results in a better sharing of an economy's risk with other countries. The existence of cross-border banking can also increase competition for domestic banks. An important strand of the literature has shown that more competition is beneficial to stability (e.g. (Boyd and De Nicolo, 2005)).

The diversification benefits and interaction between competition and efficiency appear to be more apparent in the financial industry. The foreign bank entrance and competition between banks generate a greater variety of financial services at a lower price. For example, lower lending rates for borrowers. A lower cost of investment will raise domestic borrowers' profits and net worth and consequently reduce the likelihood of defaults. The presence of foreign banks enables the application of more sophisticated banking techniques and highly advanced risk management systems that help to improve the quality of financial services and mitigate credit risk. The foreign bank penetration contributes to the stabilisation of domestic lending by offering domestic firms multiple lending relationship opportunities. When domestic banks are lending-constrained due to idiosyncratic shock, domestic borrowers may substitute domestic lending with foreign-based financing. The same benefits can be obtained on the banks' liability side. Specifically, during financial turmoil depositors may shift their funds to foreign banks that are perceived to be sounder than domestically-owned ones, instead of transferring assets abroad through capital flight. Under these circumstances, cross-border linkages increase banking system efficiency and enhance financial stability.

Financial liberalisation accompanied by free flows of capital and the effect of foreign factors may stimulate better regulation, accounting standards, and financial and legal structures. This will encourage countries to pursue more disciplined macroeconomic policies. This results in a reduction in the frequency

of policy mistakes. As mentioned in Obstfeld (1992), unsound policies (i.e. excessive government borrowing or inadequate bank regulation) may spark speculative capital outflows and higher domestic interest rates. Greater policy discipline translates into greater macroeconomic and financial stability. This ensures a more efficient allocation of resources and higher rates of economic growth.

The potential structural changes in banks' international lending activities are highly important for policymakers for several reasons. Firstly, bank lending is particularly important for small and medium-sized firms. If external funding from abroad becomes scarce, the costs of borrowing for certain groups of borrowers may significantly increase in some countries. Second, the financing of cross-border trade may suffer from increasingly segmented loan markets with adverse effects on international trade flows. Third, international banking sector integration has not only enhanced cross-border lending, but also other types of capital flows. If cross-border banking decreases, other international capital flows may reduce as well. This may imply, for instance, less risk-sharing between countries and higher external funding costs for firms. Moreover, credit market fragmentation reduces competitive pressures in the banking system (Bremus, 2015).

Despite extensive potential benefits, increased cross-border linkages have generated a great deal of concern about financial instability, such as domestic misallocation of capital flows that may hamper economic growth, risks associated with foreign bank penetration, the high degree of capital flow volatility and in particular the risks of cross-border contagion. Although, international capital inflows may stimulate domestic investment and raise economic growth. This effect may be quite limited or even become negative in the long-run if the cross-border capital flows are misallocated to unproductive investments. For example, in some catching-up countries, capital inflows are used to finance private consumption or excessive public deficits or are invested in speculative and non-tradable sectors (e.g. in real estate). Large amounts of funds invested in weak productive sections may push up inflation and real exchange rates, leading to serial problems such as low real interest rates, growing external imbalances and associated large current account deficits, excessive credit, and asset price distortions. Misallocation of capital flows usually arises in countries

with weak banks (i.e., banks with low capital to risk-adjusted asset ratios) and poorly supervised financial systems (Agénor, 2001). Easier access to the capital market by the banking system may exacerbate the moral hazards problem. The lenders may engage in riskier and more concentrated loan operations. This happened in East Asian economies in the 1990s, causing a serious banking and currency crisis in 1997-1998.

Although foreign-bank penetration generates potential efficiency and stability benefits, it may weaken the position of the domestic banking system. If domestic banks are burdened with bad debts, operate less efficiently, or are technically disadvantaged, this makes them unable to cope with competitive pressures (De Haas et al., 2002).Pardee et al. (1998) emphasised foreign competition can raise the probability of a banking crisis as lower margins for domestic banks to make them more vulnerable to loan losses. Also, foreign banks usually concentrate their credit provisions on large and often multinational firms with higher creditworthiness. This leaves domestic banks with the remaining bad corporate credit risks and the retail market. The higher degree of credit rationing to small firms and household borrowers may bring about adverse effects on output, employment, and outcome distribution. Another risk of foreign bank entrance is the concentration process arising from the pressure of mergers between local banks for them to remain competitive and the acquisition of domestic banks by foreign banks. This results in banks becoming "too big to fail". This is likely to increase the moral hazard problem and monopoly power.

Global integration with higher financial openness to cross-border transactions increases the level of capital flow volatility because it leads not only to domestic capital flight but also to large capital inflows, which are highly susceptible to the sudden reversal in times of financial distress. During the past two decades, currency or financial crises accompanied by capital withdrawals have become more frequent and severe. However, the effects of financial liberalisation on capital flow volatility are varied, depending on the form of capital flows and economic region (Broner and Ventura, 2010). For example, Foreign Direct Investment(FDI) is considered more stable and more difficult to liquidate than portfolio and other investment flows(Lipsey,2001 ;Berger and Udell,2004).

Tong and Wei (2011) conducted a test of the effect of capital flow composition in 24 Emerging Market Economies (EMEs) during the 1999-2009 period. They found that the adjustments of international bank loans are sharper than portfolio investment and much sharper than that of FDI flows. The volatile level of capital movement is also higher for short-term liabilities, which are more prone to "cut and run" by international banks during a period of financial turmoil. Additionally, the volatility in net capital flows is more severe in EMEs than in advanced economies because the change in external liabilities (i.e. a sudden stop in capital inflows) is relatively higher than an adjustment in external assets (limited capital outflows). After all, EMEs are generally less interconnected and less flexible in offsetting the changes in both inward and outward linkages. They are therefore more vulnerable to the one-way risk of deleveraging.

The highest potential cost of financial interconnection and the associated capital flow volatility is the risk of cross-border contagion. Financial literature provides many approaches to defining contagion. On one hand, cross-border financial linkages reduce investors' exposure to domestic shocks. On the other hand, investors become more vulnerable to foreign shocks. In other words, financial linkages may facilitate shock propagation across countries through various transmission mechanisms. The most obvious channel is from direct exposure, i.e. overlapping claims that different countries/regions or banking sectors have on one another. A negative shock that hits one country will cause unexpected losses in others because their claims on the troubled country fall in value. If the loss is substantial enough, it will cause a crisis in the affected countries.

Allen and Gale (2000) and Freixas et al. (2000) develop theoretical models to demonstrate that the possibility of contagion depends strongly on the completeness of the structure of interregional claims. For example, countries whose banking sectors had more exposure to structural credit products in the United States of America (US) experienced larger losses during the 2007-2009 subprime mortgage crisis. In that case, European banks were major purchasers of asset-back securities and obtained dollar funding in the US money markets Bernanke et al., 2011. Therefore, they suffered more severe sub-prime losses than EMEs in Asia or Latin America. This affected their domestic lending

and consequently led to the economic recession.

4.2.2 Determinants of Cross-Border positions

International banks may grow their foreign claims portfolio in two ways. First, the bank may establish affiliates in different countries and extend claims locally through their branches and subsidiaries in these countries. Second, the bank may also extend cross-border claims by financing and booking the claims from outside the recipient or host countries. The cross-border claims are typically extended from the bank's headquarters. The local claims involve some form of foreign direct investment in the host country's financial sector, cross-border claims do not.

Jeanneau and Micu (2002) analysed the cross-border lending to large Asian and Latin-American countries during the period 1985 and 2002. They found that the economic cycles in the lending countries might have a pro-cyclical impact on the international bank claims. Additionally, they found that the foreign bank lending flows would be encouraged in the fixed and intermediate exchange rate arrangements. However, the floating rate agreements may impede the lending flows.Peria et al. (2005) analysed the cross-country determinants and financial stability implications of the mix of international banks' foreign claims using data on Italian, Spanish, and US banks' foreign claims for the period 1997-2002. They found that the regulatory barriers to banking and restricted business opportunities in borrowing countries to have a significantly negative impact on the share of a lending bank's claim in favour of cross-border claims. Furthermore, they found that the foreign claim volatility is lower in countries with a larger share of local claims. Papaioannou (2005) using data on 40 lending and 140 recipient countries for the period from 1984 to 2002 to assess how institutions affect international lending. They found that the major obstacles for foreign bank lending to emerging markets to be under-performing institutions in recipient countries. These under-performing institutions have weak property rights, legal inefficiencies, or a high risk of expropriation. Additionally, he suggested that the political liberalization, privatization, and other structural policies might enable local economies to attract substantially more foreign bank capital.

Herrmann and Mihaljek (2013) examined the impact of financial distress in the source and recipient countries on the international bank lending based on the cross-border bank flows between 17 advanced and 28 emerging countries during the period 1993-2008. They found that the country-specific risk factors to be significant determinants of cross-border bank flows. They identified that increasing expected global financial market volatility, higher fiscal deficits and deteriorating banking sector performance in emerging markets along with loose financial and monetary linkages between the source and the recipient country to reduce cross-border banking flows.

Buch and Goldberg (2015) (2009) examined the relationship between macroeconomic shocks and changes in the international bank's foreign assets using a sample of 17 OECD countries during the period 1999 to 2006. They found that temporary overshooting and subsequent adjustment over several quarters characterized the bank lending. Also, they found banks reduce their foreign assets in response to a relative increase in domestic interest rates, and they increase their foreign assets when the growth rate of world energy prices rises.

Houston et al. (2012) investigated whether the cross-country differences in regulations have affected the international banks' flows. They use data on international bank flows from 26 lending countries to 120 borrowing countries for the period from 1996 to 2007. They found that the banks transferred funds to markets with fewer regulations. This form of regulatory arbitrage restricted the domestic regulator's ability to limit bank risk-taking. Additionally, they found that the links between regulation differences and bank flows are significantly stronger if the recipient country is a developed country with strong property rights and creditor rights. This suggests that differences in regulations have significant influences, however, without a strong institutional environment, lax regulations are not enough to encourage massive capital flows. Ongena et al. (2013) analysed the business lending by 155 banks to 9,613 firms in 1,946 different localities across 16 European countries over the period 2005-2008. They found that the lower barriers to entry, tighter restrictions on bank activities, and to a lesser degree higher minimum capital requirements in domestic markets are associated with lower bank lending standards abroad. Furthermore, they found that higher restrictions on non-core bank activities such as bank involvement in securities markets, insurance, real estate, etc. may result in

banks are less efficiently supervised at home, and are observed to exist independently from the impact of host-country regulation. These findings point to the possibility that there could be more risk-taking activities for multinational banks when they enter a less restrictively regulated banking market.

4.2.3 Cross-border banking and financial crises

Numerous researchers have looked into the volatility in cross-border banking flows, especially the adjustment in international lending during crisis episodes, with various pull and push factors. The pull factors deal with the reduction in lending from international bank's reactions to the economic and financial disturbances in the host country. This was witnessed by simultaneous withdrawals of global banks from emerging economies during the financial crises of the 1990s (Mexico in 1994, East Asia in 1997-1998, Brazil and Russia in 1999, Turkey in 2000 and Argentina in 2002). The push factor corresponds to the spillovers from home country shocks through credit contraction by parent banks or foreign affiliates and branches. Most of the recent studies of the global financial crisis stress the significance of global push factors, especially, risk, liquidity, interest rates, and growth.

The market liquidity failures intensified the recent global financial crisis. This is comparable to a bank run on a liquid market, which changes liquid securities to illiquid loans, following a shock that makes traders and asset holders uncertain regarding the underlying assets value (Davis, 2008).Adrian and Shin (2010) indicated that market liquidity failure reflects contagion through market price changes. This means financial institutions manage their balance sheets in response to measured risk and price changes.Barrell and Davis (2008) found that when a bank's balance sheet is strong, the bank has low leverage and seeks to extend its balance sheet through increased lending and short-term liabilities incurrence. This is witnessed as enhanced liquidity across the whole. Therefore, the bank was able to lend to sub-prime borrowers in the run-up to 2007. When there is a market price shock, financial institutions, which mark to market, find their leverage high and seek to reduce their balance sheets that required ceasing to lend in the interbank market.

Another important source of financial instability resulted from exposure to bad financial debt, which arose from real estate bubbles. It is argued that

the bubble in real estate prices in the U.S. caused the global financial crisis. Financial fragility led to an over-expansion in housebuilding in other countries, such as Spain and Ireland. This influenced the banks in these countries for their capacity to respond to the crisis in the Eurozone. The overvaluation of house prices and subsequent fall affected the financial institutions. This led to bank failures in the U.S., U.K., and Ireland, which affected the real economy. In the U.S., this was compounded by the failure in the securitised mortgage markets and markets for assets such as mortgage-backed securities (MBS). These securities were then held by European banks either by the purchase of the derivative assets or of financial institutions that held them. As a result, the crisis spread quickly from the U.S. to Europe.

Most of the assets backed by sub-prime loans were offloaded by the banks. In the early months of the crisis,Greenlaw et al. (2008) shows that there was a big amount of recapitalisation from sovereign wealth funds. The dynamics of the crisis was vastly been affected by cross-border banking. The European banks were holding U.S. securities such as MBS and CDS. This made European banks exposed to the U.S. crisis. This was the result of the global banks operating on either the selling or buying side. The nature of failure in credit and collapse in asset markets was global which fed across borders because of the complex linkages through the global ownership of financial assets. The nature of the crisis caused a severe shortfall in liquidity among the European banks, which were short of US dollars. This situation had to be resolved. Therefore, the solution for the shortage was resolved through a currency swap initiative by the major central banks. The market liquidity failure for securitised loans affected the banks because of mark-to-market pricing. As the price decreased, it affected the solvency. In the past banking crises, loans have been held at a known cost with no specific price. This made the global financial crisis different from past crises.

The effect of the financial crisis on cross border banking can occur in the lender country, borrower country, or both countries at the same time. However, this depends on the nature of the crisis. The existing studies have mainly emphasises on the importance of banks which are directly experienced a crisis in the lending country. In the literature, the banks decrease their local lending and their cross-border lending (Takáts,2010 and Herrmann and Mihaljek,2013.

Also, this occurs with a decrease in the local lending by foreign office (Cetorelli and Goldberg, 2011). The reduction in cross-border lending is limited to the banks, which are geographically closer to the borrower and have a domestic office or strong historical ties to the domestic banks (De Haas et al., 2011) .

In the literature, there seems to be a consensus that the financial crisis limits international banking. From a customer point of view, one might reach a different conclusion as crises in the home country can lead to domestic credit rationing and induce borrowers to look for funding in stable countries abroad. On the other hand, this increase may be dampened by the foreign bank's concerns about lending across borders due to substantial information asymmetries in the retail sector. Additionally, the peculiarities of the nation's legal system make it more difficult for foreign banks to work efficiently and effectively handle a default and collateral recovery. Therefore, the observed effects of banking crises on cross border lending will depend on the interaction of borrower's demand and lender's supply. This will show which effect dominates.

Banking crises will lead to more loans when credit rationing at home is more severe than informational imperfection. However, once cross-border lending increases the effect is likely permanent after banks and customers have invested in overcoming informational imperfections. In contrast, there is limited evidence for deposits in the literature. Some studies investigated the determinants of cross-border deposits or considered banks' overall cross-border liabilities. However, none of these studies considered the impact of financial crises.

Ferri et al. (1998) found evidence for a "flight to quality (safety) by depositors" during the Asian crisis of 1997/08. The depositors in Indonesia, Korea, Malaysia, the Philippines, and Thailand turned to safer foreign banks operating in these countries. By analysing depositor behaviour during crises, there is a clearer picture of the effects of the crisis has on cross-border banking. As deposits are not hampered by information asymmetry problems. Depositors can exercise direct market discipline by withdrawing deposits or by requiring higher rates of return from riskier banks. Discipline incentives are strongest in the absence of deposit insurance or for uninsured depositors who risk losing their deposits above the deposit-insurance ceiling.

Empirical evidence for direct market discipline is weak except for periods of crisis when depositors are able to "vote with their feet" (Rochet, 2004).(Park

and Peristiani, 1998) found that during the U.S. savings and loan crisis thrifts paid higher deposit rates but attracted less insured as well as uninsured deposits. Peria et al. (2005) found similar effects during the banking crises in Argentina, Chile, and Mexico in the 1980s and 1990s. Demirgüç-Kunt and Huizinga (2004) states that deposit insurance schemes depend on their specific features, which can either increase or decrease market discipline. This means that during crises, the depositors do not perceive the deposit insurance scheme as fully credible.

Herrmann and Mihaljek (2013) showed spillovers effects on bank lending flows from advance economies to emerging market economies through different channels such as the weak performance of banks in advance economies global financial market volatility and global risk aversion, measured by the spreads between US corporate bond yields and 10-year Treasury bond yields.Rai and Kamil (2010) investigated the effect of the global credit crunch on foreign banks' lending to emerging market economies. The result showed that the weakening of parent banks' financial health and a decrease in the economic growth of the home country consistently lead to slower growth in international banks' lending to Latin America. Specifically, a rise in one standard deviation in parent banks' Expected Default Frequency is associated with a 1.5 percentage point average decrease in the growth rate of foreign banks' lending in the subsequent quarter. These results are consistent with the findings ofCihák and Brooks (2009) that bank loan supply in the euro area moves in line with parent banks' financial soundness. Similarly,Popov and Udell (2010) confirmed the hypothesis that the credit crunch was transmitted to CEE following the contraction in parent and foreign banks' balance sheets caused by losses on financial assets and deterioration of their equity positions.

While some researchers have emphasised the 'pull factors' as key drivers of cross-border banking flows, especially domestic fundamentals, fiscal position, country specific risks, financial policies, and external exposure through trade and financial links. Derviz and Podpiera (2007) found that host country factors instead of home country ones are particularly important as a source of cross-border lending contagion. Influential host economic development variables include inflation, long-term interest rates, and exchange rate volatility, while the equivalent variables for the home country appear to be insignifi-

cant.Hawkins (2003) showed that internal bank lending to emerging economies is subject to the strength of both home and host countries, which is captured by their respective returns. However, it is found that the pull factors to be much stronger than the push factors.

Contagion factors have been considered in terms of the structure of cross-border banking flows. Besides the existence of common lenders,Geršl et al. (2007) analysed two other main factors that increase the vulnerability in the CEE banking system. These factors are maturities of cross-border exposures and funding concentration. According to BIS, banks' short-term claims fell much more during the crisis than long-maturity claims, which suggests the dominant effect of bank deleveraging. Moreover, if the foreign bank claims of a country are concentrated with one large creditor, when that creditor is hit by a shock that forces it to liquidate foreign investments, the impact on the debtor country will certainly be greater than if the domestic economy uses foreign capital from several countries.Rai and Kamil (2010) argued that the size of foreign banks' lending response to shocks depends on their lending structure. Cross-border lending flows which are largely denominated in foreign currencies and funded in wholesale markets, experience much higher volatility. Lending flows from foreign affiliates and branches are less volatile because they are mostly denominated in local currencies and financed by domestic deposits.Hoggarth et al. (2010) examined the dynamic international bank capital flows from the perspectives of borrowers. They concluded that withdrawals were much greater with bank funding flows to non-related banks than the banking sector, with cross-border lending than lending from foreign subsidiaries, and over a shorter period. A possible reason is that banks are more likely to reduce exposures in markets where they have less knowledge of their customers.

In addition to global and country-specific risks, another strand of literature emphasises regional contagion factors and the structure of cross-border banking flows as determinants of the sudden reversals in international lending. For example, the importance of the common lender effect of contagion was empirically investigated by Kaminsky and Reinhart (2000),Salgado et al. (2000),Hernández and Valdés (2001),Van Rijckeghem and Weder (2003),Peria et al. (2005) and Pontines and Siregar (2014). All of them found that the

vulnerability to the risk of the sudden stop could spread among clusters of countries that depend on the same lenders. Additionally,Salgado et al. (2000) showed that the countries, which are most important to the common lenders, are more likely to experience financial crises than those, which only receive a very small proportion of the common lenders' total lending. Van Rijckeghem and Weder (2003) investigated the withdrawals of common lenders, which led to remarkable capital outflows from emerging economies during the Mexican, Asian and Russian crises. However, in the Russian crisis, a more general reversal of bank flows was due to the wake-up call effect caused by a sudden increase in banks' risk aversion, even if financial links via common lenders were weak among these emerging economies. Also,De Haas et al. (2011) looked into the importance of the wake-up call effect. They found that the sub-prime mortgage problem in mid-2007 acted as a wake-up call for banks to review their screening and monitoring standards. This lead to a significant shrinking of syndicated loans in both advanced economies and emerging economies.

4.2.4 Liquidity and Cross-Border Banking

An extensive literature has established that the two main global liquidity components, cross-border loan, and bond flows through market-based participants, are impacted not only by local factors but also by global factors.Cetorelli and Goldberg (2011) using quarterly data for U.S. banks for the period 1980 – 2005 investigated the internal capital markets among the banks and the internal flows of funds within a banking organisation are systemically associated with the changes in the monetary policy. They found that the transmission of impulses through global banks to their affiliate locations internationally via internal capital markets follows a pecking order, with the degree of shock transmission to countries dependent on their bank-specific importance in lending and funding activity (Cetorelli and Goldberg, 2011). Further, they concluded geographic national boundaries are increasingly losing significance in evaluating the effects of domestic shocks and the rise of global banking is an effective vehicle of transmission across borders.

Forbes et al. (2017) using bank-level data from the U.K. investigated the deglobalisation in cross-border bank lending. They found that increases in micro-prudential capital requirements tend to reduce international bank lend-

ing and some forms of unconventional monetary policy can increase this effect. In the U.K., the Funding for Lending Scheme significantly amplified the effects of increased capital requirements on cross-border lending. Quantitative easing did not appear to have a similar effect and countries with stronger prudential capital regulations were partially insulated against the effects of these changes in UK policy. Similarly,Damar and Mordel (2016) investigated how the changes in prudential requirements affect cross-border lending of Canadian banks. They found that when a destination country tightens local prudential measures, Canadian banks increase the growth rate of lending to that jurisdiction, and the effect is particularly significant when capital requirements are tightened and weaker if banks lend mainly via affiliates. Furthermore, they showed that Canadian banks adjust foreign lending in response to domestic regulatory changes.

Bank's balance sheet characteristics are significant for the response to shocks. Higher bank capital, and more retention of bank earnings, reduce the cost of debt financing, increases bank lending growth, and reduces the magnitude of monetary policy transmission into lending (Gambacorta and Shin, 2018). US monetary policy tightening and episodes of dollar appreciation are associated with deleveraging of global banks, reduced capital flows to emerging markets, and an overall tightening of global financial conditions (Bruno and Shin, 2015).Cornett et al. (2011) examined how the banks managed the liquidity shock during the financial crisis of 2007-2009. They found that banks with more illiquid asset portfolios, i.e., those banks that held more loans and securitized assets, increased their holdings of liquid assets and decreased lending. In addition, they showed that banks that relied more heavily on stable sources of financing, i.e., core deposits and capital, continued to lend relative to other banks.

Buch and Goldberg (2015) found that liquidity conditions affecting parent banks transmit into both the domestic and foreign lending of the banks in the sample. Large and small banks differ in their response to liquidity shocks. For many countries, the large banks are the internationally active banks. However, exposure to liquidity risk depends on the type of home market, in particular, whether a country has been home or host to internationally active banks. Furthermore, they found internationally active banks have used internal capital

markets as an additional channel of adjustment to liquidity risk, both during normal times and during the crisis. Banks increased net borrowing from affiliates as liquidity risk rose in order to support domestic and cross-border lending. Caccavaio et al. (2014)assessed the extent of liquidity shocks has an impact on domestic and cross-border lending of Italian banks. They looked for differences across banks depending on their international exposure and accounts for the effects of the sovereign debt crisis and the ECB's nonconventional monetary policy measures. Using the Euribor-Eonia spread as a measure of liquidity stress, results showed: individual bank characteristics have a limited effect on lending, with little difference across banks with and without foreign affiliates. When using the proxy liquidity stress with the spread on Italian sovereign bonds (10-year BTP-Bund spread), they found that banks without foreign affiliates reduce lending more than other banks when the spread widens.

Segalla (2015) examined how different types of banks adjust their balance sheet positions in response to a liquidity shock. It distinguishes between different definitions of lending activities, such as changes in domestic C&I lending, foreign C&I lending, total credit, cross-border claims, foreign offices local claims, and internal borrowing between affiliated banks. The results showed smaller banks (parent banks without affiliates) response to liquidity risk depends on core deposit funding for foreign C&I lending and total credit. The cross-sectional differences in large banks (parent banks with affiliates) in response to liquidity risk cannot be uniformly explained by one particular ex-ante determinant. The growth of cross-border claims is negatively correlated with a higher share of illiquid assets (Illiquid Asset Ratio) and with a higher share of capital and positively correlated with the commitment ratio.

Cetorelli and Goldberg (2011) examined the relationships between adverse liquidity shocks on main developed-country banking systems to emerging markets across Europe, Asia, and Latin America, isolating loan supply from loan demand effects using 17 source countries and 94 destination countries from the emerging market. They found that the direct transmission of the shock is through the cross-border lending of source countries. The indirect transmission takes place through the internal capital markets of globalized banks, where reduced support of emerging market affiliates or increased outflows from emerging markets trigger reduced lending at home by these affiliates. Further-

more, they demonstrated that both foreign-owned banks and local stand-alone banks are expected to be impacted by foreign liquidity conditions but to differing degrees. These magnitudes are based on their exposure to cross-border funding and to the internal capital markets of the broader banking organizations in which they participate.

4.2.5 Efficiency and Cross Border Banking

Cross-border banking activities require banks to operate in a country different from their home country. Microeconomic theory of market contestability states that, with weak market barriers to entry and assuming that local firms wish to deter new entries, the former has to be efficient; otherwise, new firms would have competitive advantages (Baumol, 1986). The idea behind this theory is that technological differences are supposed to be an important feature of firms' competitive capacity so that using a more advanced banking technology in a country could be a barrier to new entries. For determining how efficiently banks set up their products, some works have used a common efficient frontier to control for the variability in bank performance across borders. When the aim is to control the efficiency of banks operating in the same market, the particular environment where banks develop their activity becomes a relevant factor that could explain efficiency differences.

Numerous researchers have shown that environmental conditions affect the efficiency scores of cross-border banking analysis. Dietsch and Lozano-Vivas (2000) investigated the efficiency of French and Spanish banks. By including the environmental variables, the results showed that the differences between both banking industries are reduced substantially. They concluded that neglecting these variables leads to important misspecification of the common frontier and overestimates inefficiency. Further, they suggested that in terms of cross-border competition, banks entering each other's market seem to have to accommodate to the different environment.Chaffai et al. (2001) analysed the productive differences of banks in France, Germany, Italy, and Spain. They used a Malmquist type index, which allows productivity gaps among banking industries in different countries to be measured and the difference to be broken down into difference due to pure technological effects and differences due to environmental effects. The index takes into account the domestic environmen-

tal conditions in which the banks operate. The results indicate on average, the differences due to environmental conditions always are larger than the differences in banking technology. They conclude that ignoring environmental conditions could lead to inaccurate conclusions when important issues such as the competitiveness of banking markets and the opportunities for cross-border consolidation for the future of the banking industry are considered. Numerous researchers have supported the role of environmental conditions influencing efficiency. This suggests that environmental conditions influence banks' cross-border activity.

Lozano-Vivas et al. (2001) investigated the role of environmental conditions of another country on the bank in one country. The results indicate that adverse (advantageous) environmental conditions are a positive (negative) factor for the home banking industry and being technically efficient appears to be a significant deterrence to foreign competition. This suggests that advantageous (adverse) environmental conditions are an aid (obstacle) for cross-border banking activity. Using a sample of 700 banks in 11 European countries,Lozano-Vivas and Pastor (2010) analysed whether banking technology and environmental conditions act as barriers for the entry of foreign banks in each European banking industry. The results show that being technologically advanced appears to be a significant deterrent to foreign competition and adverse environmental conditions constitute a real barrier for cross-border banking activity. Additionally, host-nation banking performance is a good safeguard against cross-border competition due to the differences in available technology and environmental conditions.

Amihud et al. (2002) examined the effects of cross-border bank mergers on the risk and (abnormal) returns of acquiring banks. The results suggest that whether an acquirer's risk rises or falls, following a cross-border acquisition is highly idiosyncratic. There is no evidence that cross-border merging banks add to the risk exposure of either domestic or host country regulators, whether looking at the total risk of the acquirer or its systematic risk relative to various banking industry indexes (home, host, and world).Fraser and Zhang (2009) provided evidence on operating performance changes in a sample of U.S. banks acquired by non-U.S. banking organisations over the 1980–2001 period. The results indicate that foreign acquirers of U.S. banks have generally acquired

U.S. targets that were slightly below the industry norm in terms of their cash flow performance. The foreign parents were able to improve the performance of the targets. The evidence of improvement in performance includes a more efficient usage of labour and no increase in loan loss.

4.3 Weighted Russell Directional Distance Model

The directional distance function developed by Chambers et al. (1996) and Chambers et al. (1998) assumes that the inputs and undesirable outputs are contracted and desirable outputs are expanded at the same.Therefore, they may still be treated as a radial measure of efficiency. From the perspective of axiomatic approach on efficiency measurement, radial measure may be more favourable as the efficiency function has some desirable mathematical characteristics (Sahoo et al., 2011). However, radial efficiency measures may overestimate the efficiency when there exist non-zero slacks (Fukuyama and Weber, 2009).The undesirable outputs are ignored in almost all these measures (Chen et al., 2014). In practice, there are some cases in which both outputs which are desirable (goods) and undesirable (bads; such as bad loans) are produced jointly.It is important to consider not only all the inefficiency sources of inputs and desirable outputs but also all the inefficiency sources of undesirable outputs when we evaluate the performance of a decision making unit (DMU).Several studies have investigated how to incorporate the slacks to provide a meaningful efficiency measure (Barros et al., 2012; Fukuyama and Weber, 2009).

Following by Chen et al. (2014) and Barros et al. (2012), Weighted Russell Directional Distance Model is used to measure the productive inefficiency. Chen et al. (2014) argued that the non-radial model can compute inputs and outputs inefficiency individually in addition to the overall inefficiency score. This is not possible with the radial models because they are based on the assumption of proportional changes in inputs and outputs. Chen et al. (2014)proposed a measure based on directional distance function which is evaluated in linear form. As a result, it possesses the attractive advantages of easy computation and easy extension of incorporating the additional undesirable outputs into the programming problems.WRDDM allows for not only the technical inefficiency associated with desirable output, undesirable output and input to

be different, but also allows the technical inefficiency among each of the desirable outputs, the undesirable outputs and the inputs to be different (Chen et al., 2014).This allows to identify the source where we need to improve most.This contribution effect cannot be determined in conventional productive inefficiency analysis. The contribution effects enable us to discuss how and why such firms successfully decreased their productive inefficiency.Another advantage of WRDMM over the traditional directional distance function model is that it directly incorporates weights to consider the appropriate relationship among input and output items, while the traditional model weights them equally.WRDDM takes into account for all the slacks for the inputs, desirable outputs and undesirable outputs. This allows the model to provide more accurate results performance evaluation results Chen et al. (2014).By using WRDDM, we can quantify the affect on the bad loans on the technical efficiency of the banks.This will allow to us to identify which resource uses or production of outputs (including goods and bads) need to be improved most.

Let inputs be denoted by ϵR_+^N , good outputs by y ϵR_+^M , and undesirable outputs by b ϵR_+^L . The directional distance function seeking to increase the desirable outputs and decrease the undesirable outputs and inputs directionally can be defined by the following:

$$\overrightarrow{D}(x, y, b|g) = sup\ (\beta : (x + \beta g, y + \beta g, b + \beta g)\epsilon\ T) \tag{4.1}$$

where the vector $g = (g_x, g_y, g_b)$ determines the directions in which inputs, desirable outputs and undesirable outputs are scaled. The technology reference set $T = (x, y, b) : x\ can\ produce\ (y, b)$ satisfies strong disposability of desirable outputs and inputs, and weak disposability of undesirable outputs.

Suppose there are $j = 1, 2, ..., k, ..., j$ firms in the dataset. Each firm uses inputs $x = x_1, x_2, ..., x_N \epsilon R_+^N$ to jointly produce outputs $y = y_1, y_2, ..., y_M \epsilon R_+^M$ and undesirable outputs $b = b_1, b_2, ..., b_L \epsilon R_+^L$.The WRDDM for inefficiency calculation of the firm k can be described as follows:

$$\overrightarrow{D}(x, y, b|g) = maximize(\frac{1}{N}\Sigma_{n=1}^{N}\beta_n^k + \frac{1}{M}\Sigma_{m=1}^{M}\beta_m^k + \frac{1}{L}\Sigma_{l=1}^{L}\beta_l^l) \tag{4.2}$$

subject to

$$\Sigma_{j=1}^{J} z_k y_{mj} \geq y_{mk} + \beta_m^k g_{ymk} \qquad , m = 1, \ldots., M \tag{4.3}$$

$$\Sigma_{j=1}^{J} z_k b_{ij} = b_{lk} + \beta_l^k g_{blk} \qquad , l = 1, ..., L \tag{4.4}$$

$$\Sigma_{j=1}^{J} z_k x_{nj} \leq x_{nk} + \beta_n^k g_{xnk} \qquad , n = 1, ..., N \tag{4.5}$$

$$Z_j \geq \ 0, j = 1, 2, \ldots, k, \ldots, J \tag{4.6}$$

where β_m^k,β_l^k and β_n^k are the individual inefficiency measures for desirable outputs, undesirable outputs, and inputs ,respectively. Z_k is the intensity variable to shrink or expand the individual observed activities of firm k for the purpose of constructing convex combinations of the observed inputs and outputs. To estimate productivity change indicators, we set directional vector $g = (g_{xnk}, g_{ymk}, g_{blk}) = (-x_{nk}, y_{mk}, -blk)$. The WRDDM is shown as follows :

$$\overrightarrow{D}(x, y, b|g) = maximize(\frac{1}{N}\Sigma_{n=1}^{N}\beta_n^k + \frac{1}{M}\Sigma_{m=1}^{M}\beta_m^k + \frac{1}{L}\Sigma_{l=1}^{L}\beta_l^l) \tag{4.7}$$

subject to

$$\Sigma_{j=1}^{J} z_k y_{mj} \geq y_{mk}(1 + \beta_m^k) \qquad , m = 1, \ldots.., M \tag{4.8}$$

$$\Sigma_{j=1}^{J} z_k b_{ij} = b_{lk}(1 - \beta_l^k) \qquad , l = 1, ..., L \tag{4.9}$$

$$\Sigma_{j=1}^{J} z_k x_{nj} \leq x_{nk}(1 - \beta_n^k) \qquad , n = 1, ..., N \tag{4.10}$$

$$Z_j \geq \ 0, j = 1, 2, \ldots, k, \ldots, J \tag{4.11}$$

This type of directional vector assumes that an inefficient firm can decrease productive inefficiency while increasing desirable outputs and decreasing undesirable outputs and/or inputs in proportion to the initial combination of actual inputs and outputs. The advantage of the directional vector is that it yields a straightforward interpretation of the inefficiency score.It will allow to identify the source which needs to improve the most.

By using WRDDM, the study will incorporate bad loans in into account for technical efficiency measurement. This will provide a more comprehensive efficiency results.Furthermore, WRDDM allows to identify variable-wise inefficiencies on which inefficient banks need to focus.WRDDM is able to determine each variable's contribution effect on efficiency. This is one of the strong points of the WRDDM. This contribution effect cannot be determined in conventional productive inefficiency analysis. The contribution effects enable us to discuss how and why such firms successfully decreased their productive inefficiency.

4.4 Methodology

4.4.1 Variables

Inputs and Outputs

The review of the cross-country studies indicates that the intermediation approach is most commonly used. This is consistent with the modern empirical literature of studies, which examines individual countries. Following these studies, the intermediation approach is adopted. The model is estimated using 3 inputs, 2 outputs, and 1 bad output. The inputs are the number of full-time employees(Labour), total deposits, and physical capital(Fixed Assets) that is defined as a sum of premises and real estate plus bank premises and equipment. The outputs are Total Loans that exclude NPLs, securities, and Other Earning Assets.An undesirable output is Bad Loans. Bad Loans include past-due loans in arrears by 6 months or more, Loans in arrears by 3 months or more and less than 6 months, Restructured loans, Bankrupt and quasi-bankrupt assets, Doubtful assets, Substandard loans. Table 4.1 presents descriptive statistics for the inputs and outputs.

Table 4.1: Description of Inputs and Outputs for WRDDM.WRDDM is used for calculating efficiency scores.

Inputs	**Outputs**
1.Number of Employees (Labour)	1.Loans
2.Deposits	2.Other Earning Assets
3.Physical Capital (Fixed Assets)	3.Bad Loans

Control Variables

In this study, five bank-specific, liquidity shock, one country-specific domestic exposure, and cross-border exposure control variables have been used. The country-specific variable account for the macroeconomic conditions. The bank-specific variables are: LOGTA is the logarithm of bank's assets and controls for bank's size; NPL is loan loss provisions over total loans and is a measure of Asset Quality; ROE is the pre-tax profit divided by equity; EQAS is equity to assets ratios and is a measure for the capital strength of the bank and LOANTA is total loans over total assets and is a measure of loan activity.

These variables have been used in the past studies to reveal the bank-specific characteristics that have an impact on the efficiency (Pasiouras et al., 2006; Pasiouras, 2008b).

To identify the impact of liquidity shock, the study follows Sarmiento (2018) methodology. First, we use the bank's deposits outflow as our measure of idiosyncratic liquidity shocks, based on that banks suffer from liquidity shocks associated with unexpected withdrawals by their depositors that condition their liquidity. Therefore, if the bank suffers a deposits outflow in t-1, it may force the bank to borrow in t from the interbank market, and depending on the bank's characteristics and market conditions it may entail a greater borrowing cost. The study defines the borrower's $LiquidityShock_{it}$ as a dummy variable equal to 1 if the rate of change of the deposits of the bank is negative in t-1 and, 0 otherwise.

Earlier studies have used different variables for controlling the macroeconomic conditions. In this study, annual growth in GDP is used for controlling the macroeconomic condition. Earlier studies have found that favourable conditions would be affecting positively the demand for the supply of banking services and would possibly contribute towards an improvement in the bank's efficiency. Maudos et al. (2002) found that the banks operating in expanding markets proxy by the real growth rate of GDP present higher levels of profit efficiency. However, under expansive demand conditions, banks would feel less pressurised to control their costs and could be less cost efficient.

The key challenge in this area of research is to get a complete overview of the cross-border positions of banks, as there are no regular reporting standards for banks' foreign exposures split by country. Following, the study follows Duijm and Schoenmaker (2018) methodology to get a complete overview of cross-border positions including those via branches. Due to the absence of a standard reporting format, some assumptions and simplifications had to be made. Firstly, the majority of banks report their foreign exposures in loans or assets. As we are especially interested in banks' credit exposures to other regions, we had an order of preference for exposures reported in i) loans; and ii) assets.

Table 4.2: Description of control variables used in Honore's Tobit regression model.

Variable	Description	Remarks
Bank Characteristics		
LOGTA	Logarithm of total assets	Size
NPL	Loan loss provisions over total loans	Asset Quality
ROE	Pre-tax profit divided by equity	Profitability
EQASS	Equity to assets	Capital Strength
LOANTA	Total loans over total assets	Loan Activity
Macroeconomic Conditions		
GDPGR	Real GDP growth	Overall economic condition
Cross-Border Exposure		
DEXP	Domestic Exposure in Loans or Assets	Domestic Exposure
FEXP	Foreign Exposure in Loans or Assets	Foreign Exposure
EUROEXP	Foreign Exposure in Loans or Assets in Europe not including domestic exposure	Europe Exposure
NAMEXP	Foreign Exposure in Loans or Assets in North America	North America Exposure
AFEXP	Foreign Exposure in Loans or Assets in Africa	Africa Exposure
ASEXP	Foreign Exposure in Loans or Assets in Asia	Asia Exposure
SAMEXP	Foreign Exposure in Loans or Assets in Asia	South America Exposure
LIQSHOCK	Dummy variable equal 1 if the rate of change of the deposits of bank i is negative in t-1 and, 0 otherwise.	Liquidity Shock

Honore's Tobit Estimator

Numerous studies have suggested ways in which environmental variables could be accommodated in the technical efficiency analysis. The environmental variables are described as the factors which could influence the efficiency of the bank. In this case, such factors are not the traditional inputs and are assumed to be outside the control of the manager (Sufian, 2009). The WRDDM scores fall between 0 and 1 making the dependent variable a limited dependent variable. The previous studies which have investigated the efficiency, have used the Tobit model. This is because it could handle the characteristics of efficiency measures. Therefore, providing the results which could provide important policy guidelines to improve performance. Accordingly, WRDMM scores obtained in the first stage are used as a dependent variable in the second stage and are regressed against bank characteristics, macroeconomic conditions, and liquidity shock.

The standard Tobit model can be defined as follows for observation (bank) i:

$$Y_t^* = \beta^{'} X_i + \epsilon_i; Y_i = Y_i^*,\ if\ Y_i^* \geq 0\ and\ Y_i = 0, Otherwise \tag{4.12}$$

where $\epsilon_i \sim N(0, \sigma^2)$, x_i and β are vectors of explanatory variables and unknown parameters, respectively, while Y_i^* is a latent variable and Y_i is the WRDMM efficiency score.

Honoré (1992) Tobit fixed effect model builds on the idea of orthogonality condition in semi-parametric and pairwise contexts. Honoré (1992) proposed a trimmed least absolute deviations and trimmed least squares estimators to secure consistency in the censored and truncated regression estimates with fixed effects. Honoré (1992) fixed effect model is defined as :-

$$Y_t^* = \alpha + X_t\beta + \epsilon_t,\ for\ t = 1, 2, \tag{4.13}$$

where X_1 and X_2 are K-dimensional vectors of explanatory variables, β is the parameter vector of interest,and α is the fixed effect,ϵ_1 and ϵ_2 are the error terms.If ϵ_1 and ϵ_2 are independent and identically distributed conditional on (X_1, X_2, α) then the distribution of (Y_1^*, Y_2^*) conditional on (X_1, X_2) is symmetric around 45° line through $(\Delta X\beta, 0)$.

The study uses Honore's fixed-effects Tobit estimator (Honoré, 1992). This estimation technique allows controlling for the differences between the countries and macroeconomic conditions. As a result, it allows only inter-temporal changes in a bank's characteristics to influence the parameter estimates. The fixed-effects Tobit estimation technique also relies on symmetry conditions imposed by a censored model, is semi-parametric, and does not require assumptions of homoskedasticity or normality. The fixed-effects Tobit estimates standard errors using the method of kernels, a procedure that involves a subjective judgement concerning the appropriate bandwidth (Silverman, 1986). The use of the bootstrap avoids this subjectivity while providing an unbiased and consistent estimate of the standard errors. The bootstrap method consists of the following steps. First, parameter estimates are made using a Monte Carlo technique that assigns a 1/n probability for each of the n sample observations. This involves creating a bootstrapped sample from the original sample by randomly pulling n observations with replacement. This procedure is repeated 500 times, creating 500 parameter estimates. The standard deviations of this sample of 500 parameter estimates is used to generate the standard errors of the parameter estimates.The standard fixed effect Tobit estimator for the bank (i) is defined as :-

$$Y_{it}^{*} = \alpha_i + X_{it}\beta_0 + \epsilon_{it} \tag{4.14}$$

$$Y_{it} = Y_{it}^{*} \; if \; Y_{it}^{*} > 0, = 0 \; otherwise \tag{4.15}$$

where Y_{it} is the variable of interest, X_{it} is a vector of explanatory variables, α_i is an individual effect and ϵ_{it} is a random error.

In this study, the fixed effect Tobit estimator is used to assess the determinants of the bank efficiency and cross-border exposures in relation to the liquidity shock. The bank characteristics, macroeconomic conditions, liquidity shock, and cross border exposures would be used in this study. The first model would be using bank characteristics and liquidity shock. The second model would be using banking characteristics, macroeconomic conditions, and liquidity shocks. The third model would be incorporating bank characteristics, macroeconomic conditions, liquidity shock, and domestic and foreign exposures. Model 4 incorporates bank characteristics, macroeconomic conditions, liquidity shock, domestic exposures, and exposures from different regions.The

study augments with year dummies to control for the time effects common to all banks and country dummies to control for time-invariant heterogeneity across industries. This allows to address the issue of heterogeneity. As any remaining unobserved heterogeneity in the sample is captured by country fixed effects and time fixed effects.

$$Y_{it}^{*} = \alpha_i + \beta_1 LOGTA_{it} + \beta_2 EQASS_{it} + \beta_3 NPL_{it} + \beta_4 LOANTA_{it} + \beta_5 ROE_{it} + \beta_6 LIQSHOCK_{it} + \epsilon_{it} \tag{4.16}$$

$$Y_{it}^{*} = \alpha_i + \beta_1 LOGTA_{it} + \beta_2 EQASS_{it} + \beta_3 NPL_{it} + \beta_4 LOANTA_{it} + \beta_5 ROE_{it} + \beta_6 LIQSHOCK_{it} + \beta_7 GDPGR_{it} + \epsilon_{it} \tag{4.17}$$

$$Y_{it}^{*} = \alpha_i + \beta_1 LOGTA_{it} + \beta_2 EQASS_{it} + \beta_3 NPL_{it} + \beta_4 LOANTA_{it} + \beta_5 ROE_{it} + \beta_6 LIQSHOCK_{it} + \beta_7 GDPGR_{it} + \beta_8 DEXP_{it} + \beta_9 FEXP_{it} + \epsilon_{it} \tag{4.18}$$

$$Y_{it}^{*} = \alpha_i + \beta_1 LOGTA_{it} + \beta_2 EQASS_{it} + \beta_3 NPL_{it} + \beta_4 LOANTA_{it} + \beta_5 ROE_{it} + \beta_6 LIQSHOCK_{it} + \beta_7 GDPGR_{it} + \beta_8 DEXP_{it} + \beta_9 EUROEXP_{it} + \beta_{10} NAMEXP_{it} + \beta_1 1 SAMEXP_{it} + \beta_1 2 AFEXP_{it} + \beta_1 2 ASEXP_{it} + \epsilon_{it} \tag{4.19}$$

where Y_{it}^{*} is the technical efficiency of the i^{th} bank obtained in period t and α_i is the country and time fixed effects.

Data

The focus is on commercial banks because it would allow us to examine a more homogeneous sample in terms of services and consequently inputs and outputs enhancing further the comparability among counties. The sample consists of the banks in 15 countries in Europe with the financial data available from Market Intelligence for the period 2005-2019. The banks were excluded from the sample for one of the following reasons: - (i) they had no data available for any of the years, (ii) they had missing or negative values for the required inputs/outputs, and (iii) they had missing values for the bank-specific control variables. The final sample consists of 1931 banks in 15 countries in Europe.

During the above procedure, we select the consolidated data only. The reports prepared under International Financial Reporting Standards are used

where available, but if only reports prepared under local generally accepted accounting principles are available, then it is used. All the data was converted to the Euro prior to downloading, using official exchange rates available in Market Intelligence. The country-specific variable is downloaded from the World Bank. The Financial Development Index data is downloaded from IMF.

Using the Financial Development Index, the study divides the sample of 1931 banks into 2 sub-samples:-The countries with higher Financial Development Index and the lower Financial Development Index. Financial markets include stock and bond markets. Financial development is defined as a combination of depth (size and liquidity of markets), access (the ability of individuals and companies to access financial services), and efficiency (the ability of institutions to provide financial services at low cost and with sustainable revenues, and the level of activity of capital markets).Svirydzenka (2016) developed a number of indices that summarize how developed financial institutions and financial markets are in terms of their depth, access, and efficiency, which culminated in the final index of financial development. The countries are placed into sub-samples based on its Financial Development Index being higher or lower than the average of the sample. In sub-sample with a higher Financial Development Index consists of 1229 banks in 8 countries. The sub-sample with lower Financial Development Index consists of 702 banks in 7 countries.

Table 4.3: The table presents the sub-sample of the countries on the basis of the Financial Development Index.The sample consists of 15 countries.The countries are placed into sub-samples based on its Financial Development Index being higher or lower than the average of the sample.

Country with higher Financial Development	**Country with lower Financial Development**
Austria	Belgium
Denmark	Cyprus
Germany	France
Greece	Norway
Luxembourg	Portugal
Russia	Spain
Switzerland	Ukraine
United Kingdom	

4.5 Results

4.5.1 Descriptive Statistics

Table 4.4: Summary Statistics for the Inputs and the Outputs for WRDDM.WRDDM is used for calculating Efficiency scores.The model is estimated using 3 inputs,2 outputs and 1 bad output.The inputs are the number of full-time employees, total deposits, and physical capital. The outputs are total loans and other earning assets.An undesirable output is Bad Loans.The sample consists of 1931 banks in 15 countries.The sample period is 2005-2019.Reported is the mean on yearly basis.

Year	Deposit	Labour	Fixed Assets	Loans	Other Earning Assets	Bad Loans
2005	35900	0.006	0.382	41600	72300	0.833
2006	5657.266	0.002	0.116	7656.749	11900	0.907
2007	18200	0.002	0.179	15500	35600	0.624
2008	9238.196	0.005	0.159	12700	18800	1498.895
2009	35600	0.013	0.662	47800	77600	3643.437
2010	17000	0.004	217.285	20000	38400	1389.856
2011	15200	0.004	0.391	26200	39900	2081.056
2012	7260.734	0.003	0.150	7883.195	11400	1555.355
2013	7248.936	0.002	0.084	6919.133	10900	0.292
2014	14700	0.005	0.248	19100	34200	1239.341
2015	5906.645	0.003	0.102	6899.312	10300	0.274
2016	23700	20.507	0.565	23200	32500	1618.659
2017	16100	0.002	0.120	18400	72900	0.449
2018	37200	0.012	0.425	56800	91100	5210.494
2019	14700	0.004	0.168	16700	36900	0.733
Total	14700	0.004	0.170	16800	36900	0.745

Table 4.4 presents the average for the inputs and outputs.Over the years, the inputs and outputs have increased and decreased.The state of economy has influenced the inputs and outputs over the years. During the period 2005-2019 ,Labour is mostly below the average of the period. Over the years, Other Earning Assets has increased on average.When Deposits and Fixed Assets are increasing, Loans are increasing. However, Bad Loans decline. Bad Loans increase when there is a decline in the inputs and the other outputs. On average, Bad Loans has been greater than the average of the period.

Table 4.5: Descriptive Statistics for the Inputs and the Outputs of the 15 countries in Europe for WRDDM.WRDDM is used for calculating Efficiency scores.The model is estimated using 3 inputs,2 outputs and 1 bad output.The inputs are the number of full-time employees, total deposits, and physical capital. The outputs are total loans and other earning assets.An undesirable output is Bad Loans.The sample consists of 1931 banks in 15 countries.The sample period is 2005-2019.Reported statistics are mean,maximum,minimum and standard deviation in 15 countries.

Country		Deposit	Labour	Fixed Assets	Loans	Other Earning Assets	Bad Loans
Austria	Mean	18500	317	0.009	22600	37700	1600
	Max.	163000	2476.913	67.002	151000	232000	14500
	Min.	45.540	0.180	0.058	35.655	102.455	0.000
	S.D.	31400	566	0.018	35000	54300	2790
Belgium	Mean	33600	347	0.006	53900	110000	983
	Max.	168000	1796	40.750	372000	693000	7399
	Min.	28.030	0.085	0.014	0.313	76.423	0.000
	S.D.	42900	539	0.010	77600	159000	1520
Cyprus	Mean	7340	120	3.485	7870	10800	1340
	Max.	33000	497	25.100	28900	41400	8127.296
	Min.	4.588	0.720	0.057	0.048	47.154	0.000
	S.D.	8610	153	0.006	8910	12100	1980
Denmark	Mean	4590	0.038	0.001	8770	14900	334
	Max.	142000	1040	250.900	277000	519000	15200
	Min.	0.015	0.000	0.005	0.011	0.025	0.000
	S.D.	18700	116	10.630	39200	68300	1370
France	Mean	35500	420	0.009	42400	106000	1620
	Max.	797000	9802	203.092	879000	2360000	43700
	Min.	0.022	0.002	0.008	0.890	15.513	0.000
	S.D.	107000	1270	0.029	121000	338000	5240
Germany	Mean	6780	0.057	0.001	7150	18600	206
	Max.	602000	5802	102.062	462000	3280000	13700
	Min.	0.000	0.000	0.002	0.000	7.279	0.000
	S.D.	32000	270	0.006	30700	133000	976
Greece	Mean	18500	488	0.008	23400	29700	5590
	Max.	71200	2109	37.591	80800	114000	28800
	Min.	2.428	0.092	0.029	54.959	43.622	5.491
	S.D.	20300	604	0.010	25600	33100	8570
Luxembourg	Mean	7760	0.098	0.001	6680	16700	169
	Max.	56600	1303	22.432	65700	153000	5695
	Min.	0.000	0.002	0.008	0.000	69.738	0.000
	S.D.	9630	183	0.002	9370	23000	508
Norway	Mean	3561.175	0.000	0.021	5993.228	11000	0.084
	Max.	112000	13.620	0.910	180000	2040000	3673.101
	Min.	0.000	0.004	0.000	0.000	0.001	0.000
	S.D.	14400	0.002	0.075	24000	77700	0.423
Portugal	Mean	6840	104	0.002	8490	11900	600
	Max.	73400	1184.058	23.205	84500	123000	11500
	Min.	0.000	0.011	0.006	0.000	18.398	0.000
	S.D.	14700	220	0.005	18000	24900	1660
Russia	Mean	2960	101	0.004	3270	4520	319
	Max.	290000	10800	330.677	303000	384000	27300

Table 4.5 – *Continued from previous page*

Country		Deposit	Labour	Fixed Assets	Loans	Other Earning Assets	Bad Loans
	Min.	0.000	0.000	0.006	0.000	0.002	0.000
	S.D.	18500	639	0.024	20300	26100	1560
Spain	Mean	34200	574	0.009	41300	64600	2310
	Max.	780000	8324.215	202.713	906000	1420000	40400
	Min.	0.009	0.004	0.004	0.009	19.484	0.000
	S.D.	95600	1360	0.029	116000	190000	5850
Switzerland	Mean	3940	0.042	0.000	3620	5860	0.048
	Max.	232000	2230	9.857	172000	297000	1620
	Min.	0.007	0.000	0.002	0.000	0.034	0.000
	S.D.	14000	145	0.001	12500	19800	127
Ukraine	Mean	679	0.044	0.004	1050	1210	363
	Max.	5090	293	38.876	5780	8645.114	2820
	Min.	0.004	0.000	0.020	0.000	0.010	0.000
	S.D.	804	0.064	0.006	1260	1540	543
United Kingdom	Mean	72300	590	0.016	76900	181000	3120
	Max.	1250000	9140	315.520	1140000	3420000	75400
	Min.	0.000	0.000	0.000	0.000	0.000	0.000
	S.D.	178000	1550	0.043	180000	485000	9720
Total	Mean	14700	0.004	0.170	16800	36900	0.745
	Max.	1250000	330.677	10800	1140000	3420000	75400
	Min.	0.000	0.000	0.000	0.000	0.000	0.000
	S.D.	67500	0.019	0.740	73100	195000	3681.784

Table 4.5 presents the descriptive statistics for the inputs and outputs for the 15 countries in Europe. On average, United Kingdom and Belgium have the highest loans while Ukraine and Russia have the lowest loans. However, United Kingdom and Greece have the highest amount of Bad Loans on average whereas Switzerland and Norway have the lowest. This reflects the recent financial distress witnessed in these countries. On average, the United Kingdom has the inputs and outputs more than the average of all the countries combined. On average, Ukraine, Russia and Switzerland have the lowest Other Earning Assets. This is lower than the average of all the countries combined. On average, Switzerland and Norway have the lowest labour. This reflects the role of higher wages. While the United Kingdom has the highest amount of labour. This shows that the United Kingdom holds a significant place in the banking sector of Europe.

Table 4.6 provides an overview of the geographical exposures for all the banks in the dataset, grouped by country. On average, banks invest the majority of 43.8% of their assets in their home country. Majority of the foreign exposures are held in other European countries (32.3%) and North America

Table 4.6: Cross- Border Exposures of the banks in 15 Europe countries from 2005-2019.The table shows the domestic exposures and foreign exposures by region for the 1931 European banks in the dataset, grouped per country. The data is based on the average for the period 2005-2019 , and weighted by total banking assets.

Country	Domestic	Rest of Europe	North America	South America	Africa	Asia
Austria	35.557	15.511	10.708	0.122	0.000	0.004
Belgium	31.674	11.685	0.000	0.000	0.000	0.000
Cyprus	37.164	15.237	10.060	0.000	0.000	0.000
Denmark	48.428	13.344	21.560	2.120	0.000	0.012
France	52.986	14.960	44.790	9.110	0.075	0.031
Germany	26.327	83.532	51.450	1.994	0.006	0.026
Greece	59.436	19.079	5.594	0.000	0.000	0.000
Luxembourg	55.450	41.158	7.948	0.003	0.606	0.598
Norway	62.734	55.946	7.131	0.606	0.070	0.054
Portugal	34.698	19.103	32.926	0.624	0.556	0.042
Russia	42.787	19.581	0.000	0.000	0.000	36.729
Spain	34.153	91.277	12.983	0.165	0.000	0.000
Switzerland	88.008	11.513	26.596	1.252	0.293	3.358
Ukraine	13.758	3.745	0.000	0.000	0.000	0.000
United Kingdom	33.923	69.257	32.090	5.250	0.442	12.053
Total	43.806	32.329	17.589	1.416	0.137	3.527

(17.5%). On average, banks invest the least in Africa with 0.13%, which is followed by South America with 1.4%. On average, a bank in Switzerland have invested most in their own country and bank in Ukraine invested the least. Spanish banks have invested most in the rest of Europe. The banks in Ukraine have invested the least in the rest of Europe. Russian banks have invested 36.729% in Asia, which is the most in the group. Similarly, French banks have invested 9.11% in South America, which is the most in the sample. The most invested in North America is 51.45% by German banks.

Table 4.7: Descriptive Statistics of the bank characteristics and macroeconomic variable based on their country..The sample consists of 1931 banks in 15 countries.The sample period is 2005-2019.Reported statistics are mean,maximum,minimum and standard deviation.

COUNTRY		LOGTA	NPL	ROE	EQASS	LOANTA	GDP
Austria	Mean	16.606	0.035	8.601	0.080	0.571	1.592
	Max.	19.283	0.331	58.315	0.520	0.866	3.690
	Min.	12.035	0.000	0.053	0.024	0.016	-3.550
	S.D.	1.384	0.030	7.933	0.041	0.169	0.397
Belgium	Mean	16.352	0.016	10.278	0.077	0.570	1.326
	Max.	20.220	0.084	38.516	0.163	0.921	2.860
	Min.	11.297	0.000	0.796	0.019	0.004	0.450
	S.D.	2.597	0.023	6.758	0.039	0.245	0.263
Cyprus	Mean	15.678	0.096	11.587	0.086	0.660	3.081
	Max.	17.568	0.296	49.922	0.204	1.019	4.360

Table 4.7 – *Continued from previous page*

COUNTRY		LOGTA	NPL	ROE	EQASS	LOANTA	GDP
	Min.	13.057	0.001	0.506	0.021	0.372	-6.550
	S.D.	1.424	0.092	10.373	0.036	0.160	1.753
Denmark	Mean	13.537	0.064	7.127	0.127	0.597	2.080
	Max.	19.988	0.368	51.078	0.690	0.884	3.910
	Min.	10.175	0.002	0.083	0.028	0.250	-4.910
	S.D.	2.128	0.044	5.345	0.052	0.124	0.364
France	Mean	16.193	0.030	7.070	0.100	0.668	1.249
	Max.	21.455	0.275	40.786	0.988	1.226	2.610
	Min.	9.698	0.000	0.000	0.004	0.000	-2.780
	S.D.	1.972	0.027	4.654	0.079	0.202	0.133
Germany	Mean	14.398	0.018	2.927	0.089	0.644	0.603
	Max.	21.495	0.966	91.062	0.725	19.934	4.040
	Min.	9.185	0.000	0.000	0.000	0.000	-5.640
	S.D.	1.574	0.048	4.157	0.042	0.675	0.150
Greece	Mean	15.864	0.083	9.494	0.102	0.769	2.064
	Max.	18.609	0.304	44.882	0.330	1.184	3.180
	Min.	12.104	0.004	0.068	-0.033	0.395	-4.310
	S.D.	2.341	0.089	9.336	0.076	0.158	0.827
Luxembourg	Mean	15.582	0.009	9.265	0.085	0.346	2.414
	Max.	18.459	0.088	29.104	0.180	0.795	8.340
	Min.	11.196	0.000	0.058	0.013	0.000	-4.370
	S.D.	1.829	0.014	6.102	0.036	0.206	0.902
Norway	Mean	13.891	0.008	9.421	0.095	0.821	1.008
	Max.	19.576	0.057	37.699	0.450	0.977	2.920
	Min.	10.969	0.000	0.075	0.042	0.012	-1.280
	S.D.	1.608	0.006	5.089	0.027	0.085	0.160
Portugal	Mean	13.621	0.057	9.537	0.106	0.552	1.971
	Max.	18.650	0.366	603.656	0.968	1.108	3.510
	Min.	10.114	0.000	0.059	-0.114	0.000	-4.060
	S.D.	2.304	0.049	33.913	0.086	0.212	0.382
Russia	Mean	12.984	0.111	11.054	0.165	0.574	1.213
	Max.	19.813	1.000	99.257	0.867	2.896	8.540
	Min.	8.644	0.000	0.008	-3.040	0.000	-7.930
	S.D.	1.992	0.125	10.743	0.179	0.231	0.408
Spain	Mean	15.392	0.042	6.520	0.088	0.623	2.077
	Max.	21.101	0.430	155.281	0.999	1.073	4.100
	Min.	9.901	0.000	0.012	-0.028	0.000	-3.770
	S.D.	2.694	0.030	8.366	0.076	0.214	0.393
Switzerland	Mean	13.953	0.007	4.949	0.068	0.756	0.808
	Max.	19.432	0.199	54.039	0.714	0.954	4.110
	Min.	10.661	0.000	0.000	0.006	0.000	-2.230
	S.D.	1.526	0.014	3.086	0.061	0.232	0.154
Ukraine	Mean	13.222	0.156	14.746	0.158	0.730	3.362
	Max.	16.009	0.842	96.023	0.675	1.847	7.900
	Min.	9.941	0.002	0.019	-0.731	0.000	-14.760
	S.D.	1.408	0.148	18.688	0.120	0.245	1.897
United Kingdom	Mean	15.463	0.021	9.253	0.082	0.492	1.306
	Max.	21.642	0.715	106.900	1.000	0.998	3.180
	Min.	2.664	0.000	0.000	-26.773	0.000	-0.280
	S.D.	2.882	0.059	10.157	0.959	0.249	0.116

Table 4.7 – *Continued from previous page*

COUNTRY		LOGTA	NPL	ROE	EQASS	LOANTA	GDP
Total	Mean	14.433	0.035	6.411	0.098	0.651	1.116
	Max.	21.642	1.000	603.656	1.000	19.934	8.540
	Min.	2.664	0.000	0.000	-26.773	0.000	-14.760
	S.D.	2.127	0.069	9.118	0.249	0.420	0.669

Table 4.7 provides the descriptive statistics for the bank characteristics and macroeconomic conditions for the 15 countries in the sample for the period 2005-2019. On average, NPL in Ukraine, Russia and Greece is higher than the average of the 15 countries. This reflects the problem in the asset quality especially non-performing loans in these countries over the last decade. On average, in Denmark and Russia have smaller sized banks than the average of the countries. The largest bank in the sample is located in the United Kingdom. LOANTA in most of the countries in the sample is lower than the average of the countries. The lowest LOANTA on average is in Luxembourg while Norway has the highest. EQASS represents the capital strength of the banks. On average, most of the banks have EQASS lower than the average of the countries in the sample. Denmark has the highest EQASS on average whereas Switzerland has the lowest.

4.5.2 Technical Efficiency Results

Table 4.8 presents the average technical efficiency scores for the banks and the average financial development in the country for the period 2005-2019. The average technical efficiency score of the banks in the sample is 0.184. The average bank in the sample could improve its technical efficiency by 81.6%. This means that if the average bank was producing on the frontier instead of its current location, only 18.4% of the inputs currently being used would be necessary to produce the same output vector. On average, Cyprus has the lowest average technical efficiency in the sample with 0.133. A bank in Cyprus could improve its efficiency by 86.7%. The Financial Development reflects how developed financial institutions and financial markets are in terms of their depth, access, and efficiency. The average financial development index for the sample countries is 0.744. This reflects that the financial institutions and markets in the sample countries are well developed in terms of their depth, access and efficiency. The average technical efficiency of the banks in the

Table 4.8: Efficiency Results obtained using WRDDM in the 15 countries.The sample consists of 1931 banks in 15 countries.The sample period is 2005-2019.Financial Development Index is used for sub-dividing the sample.Reported is Technical Efficiency is the average for the banks in individual country for the sample period and Financial Development is the average financial development for the individual country for the sample period.

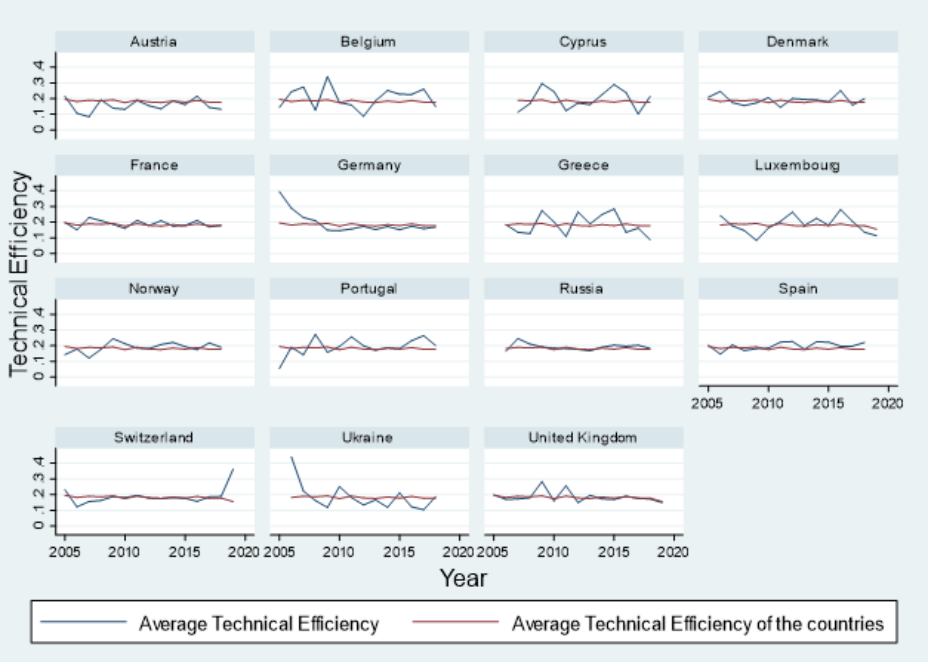
Country with high Financial Development			**Country with low Financial Development**		
Country	**Technical Efficiency**	**Financial Development**	**Country**	**Technical Efficiency**	**Financial Development**
Austria	0.202	0.72	**Belgium**	0.177	0.68
Denmark	0.191	0.742	**Cyprus**	0.133	0.704
Germany	0.191	0.823	**France**	0.165	0.688
Greece	0.234	0.757	**Norway**	0.158	0.697
Luxembourg	0.166	0.724	**Portugal**	0.203	0.687
Russia	0.221	0.745	**Spain**	0.23	0.669
Switzerland	0.14	0.71	**Ukraine**	0.216	0.709
United Kingdom	0.174	0.738			
Total for subsample	0.19	0.745		0.183	0.691
Sample average efficiency			0.184		
Sample average financial development			0.719		

country with high financial development is 0.19. The average bank in the sample could improve its technical efficiency by 81%. This means that if the average bank was producing on the frontier instead of its current location, only 19% of the inputs currently being used would be necessary to produce the same output vector. The average technical efficiency of the banks in the country with low financial development is 0.183. The average bank in the sample could improve its technical efficiency by 81.7%. This means that if the average bank was producing on the frontier instead of its current location, only 18.3% of the inputs currently being used would be necessary to produce the same output vector. The difference between the average technical efficiency of the bank is minimal. However, financial development difference is about 0.054.

By investigating the efficiency of individual countries in the sub-samples, there appear to be major differences in the technical efficiency of the banks. In the sample, Germany has the highest financial development and the average technical efficiency of the bank is 0.191. Germany can improve its technical efficiency by 80.8%. The higher financial development index ranking may be indicating the country's financial system is stretched beyond its structural and regulatory capabilities, with negative implications for growth and stability. Spain has the lowest financial development. However, the average technical efficiency of the bank is 0.23, which is the highest in the sample. This means that it could improve its technical efficiency by 77%. The financial development index captures only the characteristics and does not include their underlying drivers (such as the institutional, regulatory, and legal frameworks) or outcomes (financial stability measures).

Figure 4.1 shows the average technical efficiency of the banks across different countries for the period 2005-2019. The average technical efficiency of the countries in the sample has changed over the years. On average, the technical efficiency of the bank in the individual countries across the sample is changing over the years. The changes in technical efficiency can be explained by the changes in the inputs and outputs. When the average technical efficiency of the countries is declining, most of the inputs and outputs are decreasing. However, Bad Loans as output is increasing. When an increase in technical efficiency is witness, the inputs have declined. But, the outputs have increased. The average technical efficiency of the banks in Austria is lower than the av-

Figure 4.1: Average Technical Efficiency of the banks across different countries over time.Efficiency scores are obtained using WRDDM.Average Technical Efficiency is the average technical efficiency of the banks in the individual country. Average Technical Efficiency of the countries is the average technical efficiency of the 15 countries in the sample.The sample period is 2005-2019.The sample consists of 1931 banks in 15 countries.



erage technical efficiency of the countries in the sample. When the technical efficiency of the bank is declining, the inputs such as FA and Deposits are decreasing. The input FTE is increasing. However, the outputs such as bad loans are increasing. The other outputs such as OEA and Loans are increasing. The changes in the activities by the bank contributes towards the increase in the technical efficiency of the bank. This could be explained by the increase in the outputs such as Loans and OEA. The bank reduces bad loans. Furthermore, the inputs witness a decline as well.

The technical efficiency of the banks in the countries witnesses fluctuations over the years. Majority of the countries in the sample witness high fluctuations in their technical efficiency over the years. Russia and Switzerland have the least fluctuations in their technical efficiency. In countries such as Greece, Portugal, and Spain, the average technical efficiency witnessed a lot of fluctuations. The technical efficiency in Greece, Portugal, and Spain reflects the problems faced by these countries over time. This could be explained by the changes in the inputs and output over the years. The inputs such as Deposits, Labour and Fixed Assets have been increasing over time until 2017. The outputs such as Other Earning Assets and Loans are decreasing as well during

this time. However, Bad loans are increasing. After 2017, the efficiency of the banks is increasing. The Global Financial Crisis hit Europe in 2008. The efficiency of the banks fell to the lowest level during this time. In the following year, the efficiency of the banks started improving. However, in 2010, the Sovereign Debt Crisis hits Europe. This has resulted in the efficiency of the banks to decrease again. In the following years, the improvement in the average efficiency is helped by the improvement in the stock market. However, the improvement was much slower because Europe was once again on the brink of recession. With Greece starting to cause panic. Furthermore, this was accompanied by inflation falling to record lows in the Eurozone and collapse of the oil price.

Figure 4.2: Average Technical Efficiency of the banks across different countries over time.Efficiency score is obtained using WRDDM.A bank is defined as facing liquidity shock if the rate of change of the deposits of bank i is negative in t-1.The sample period is 2005-2019.The sample consists of 1931 in 15 countries.Average Technical Efficiency is the average technical efficiency of the banks in the individual country. Average Technical Efficiency of banks facing liquidity shock is the average technical efficiency of the banks facing liquidity shock in the individual country. Average Technical Efficiency of banks not facing liquidity shock is the average technical efficiency of the banks facing not liquidity shock in the individual country.

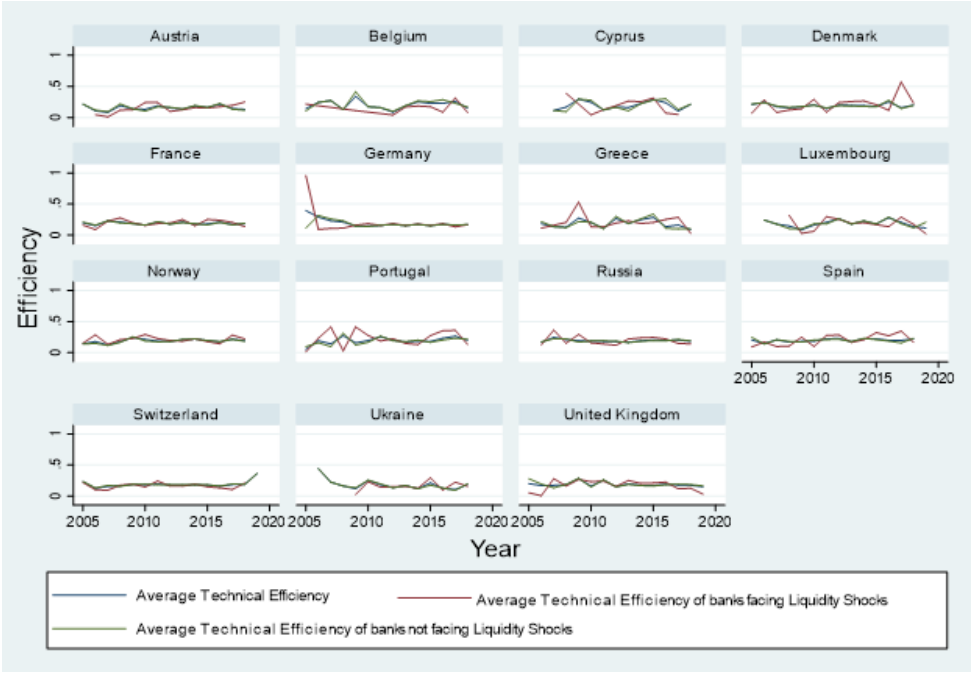


Figure 4.2 shows the average technical efficiency of the banks across different countries for the period 2005-2019 with the banks facing Liquidity Shock and not facing Liquidity Shock. The changes in the average technical efficiency

of the banks facing Liquidity Shocks can be explained by the changes in the inputs and the outputs. On average, the Technical Efficiency of the banks facing Liquidity Shocks is more unstable. This could be explained by the changes in the inputs and the outputs over the years. The bank facing liquidity shock in Greece witnessed a decline in its inputs such as Deposits, Labour, and Fixed Assets. Also, the outputs such as Loans and Other Earning Assets are declining and moving in the same direction as the inputs. However, Bad Loans is increasing when the other outputs and inputs are decreasing. This led to a decline in the technical efficiency of the banks in Greece. When the technical efficiency of the bank facing liquidity shock increases, it is because Bad Loans, Labour, and Fixed Assets are declining. But, Deposits, Loans and Other Earning Assets do not change. This reflects the efficient management of the inputs to outputs by the banks. For the banks not facing liquidity shock, the average technical efficiency of the banks is similar to the average technical efficiency of the banks in the country. The decline in technical efficiency is explained by the decrease in the inputs and outputs. However, there is a massive increase in Bad Loans. When the technical efficiency increases, Bad Loans and Labour decline while Other Earning Assets increases. Additionally, Deposits, Fixed Assets and Loans remain stable. Furthermore, this shows that the management of the inputs to the outputs differs by the banks facing liquidity shock and the banks not facing liquidity shock.

The technical efficiency of the banks facing Liquidity Shocks is much lower during the Global Financial Crisis. During the crisis, these banks witnessed an increase in Bad Loans and a decline in the other outputs and inputs. The increase in Bad Loans is greater than the decline in the other outputs and inputs leading to lower efficiency levels for these banks. However, the Sovereign Debt Crisis hits Europe. This has resulted in the efficiency of the banks to decrease. The technical efficiency of these banks recovers for the next couple of years. During this period, the banks witness a decline in Bad Loans while Other Earning Assets increases. Loans and the inputs remain stable. The technical efficiency of the banks not facing liquidity shock is more similar to the average technical efficiency of the banks. The economic events such as Oil Price Shock, Brexit, and new regulations have contributed to a greater decline especially for the banks facing Liquidity Shock. These events hit much harder

on the technical efficiency of the banks facing Liquidity Shock in comparison to the banks not facing Liquidity Shock. The banks not facing liquidity shock are able to manage their inputs to outputs more efficiently. Furthermore, the banks facing liquidity shock have a decline in their inputs especially Deposits and a massive increase in Bad Loans. This makes the efficiency of the bank to decline. Additionally, it reflects how the liquidity of the bank influences on the technical efficiency of the bank.

Figure 4.3: Average Loan Exposure , Domestic Exposure , Foreign Exposure and Technical Efficiency of the banks across the 15 countries in Europe for the period 2005-2019. Loan Exposure is the average of the Loans to Assets of the banks in the individual country. Foreign Exposure is the average of Foreign Exposure in Loans or Assets of the banks in the individual country. Domestic Exposure is the average of Domestic Exposure in Loans or assets of the banks in the individual country. Technical Efficiency is the average technical efficiency of the banks in the individual country.

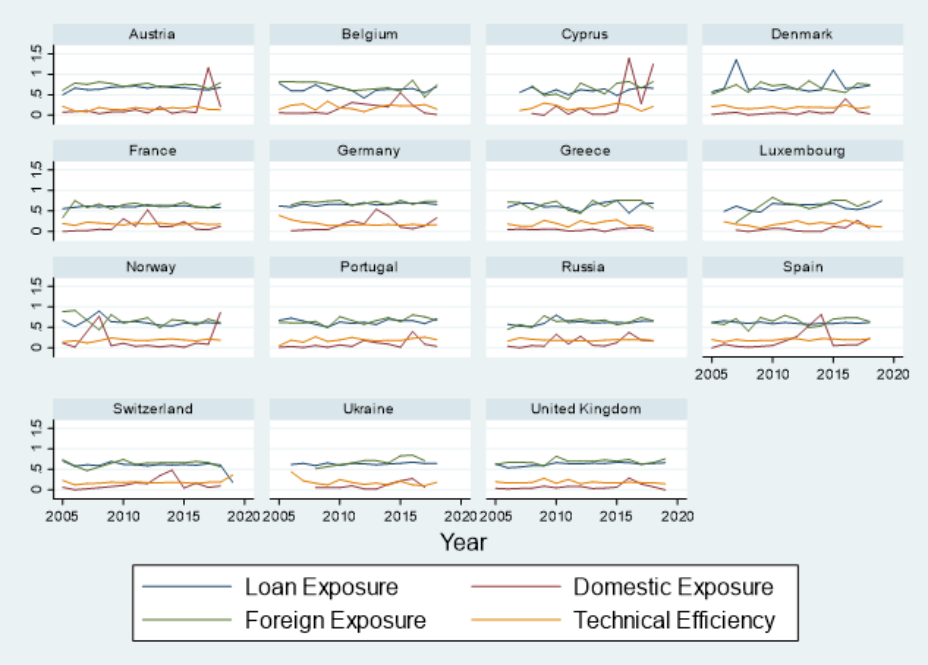


Figure 4.3 shows the average Loan Exposure, Domestic Exposure, Foreign Exposure and Technical Efficiency of the banks across different countries over time for the period 2005-2019. Foreign Exposure is increasing over the years. The changes in the foreign exposures witness among the countries is similar in most countries. However, the changes in domestic exposures is different among the countries. Domestic Exposures has been lower over the years. Both Domestic and Foreign Exposures are of Loan Exposures. But, Foreign Exposures is the major driver of Loan Exposure. This reflects that the banks are more exposed to Foreign Exposures than Domestic Exposures. The managing of

Foreign Exposures is significant for the bank's operations. The changes in Loan Exposures are reflected on the technical efficiency of the banks. This is because the role of the banks is turn inputs such as Deposits to Outputs like Loans. A decline in Loan Exposure and Technical Efficiency shows the bank's inability to convert inputs to outputs. Over the years, Banks have accumulated more Foreign Exposures in comparison to Domestic Exposures. The operations of the bank is not limited to the country where it is located. The bank is looking for different opportunities to increase its business. This is the result of globalisation. Among most countries, the changes in foreign exposures reflects on the change on the technical efficiency of the banks. In these countries, the banks are more inclined towards foreign operations for the business. The change of the economic conditions in the foreign nation is reflected on Foreign Exposures. As a result, the bank's ability to convert its inputs to outputs suffer.

Over the last few years, the banks have started concentrating on the daily operations in the host country. This has contributed towards an increase in Domestic Exposures. The changes in the local economic conditions influences domestic exposures. However, this is not reflected on the technical efficiency of the banks. As the banks have diversified the portfolio such that foreign exposure is one the major driver of the technical efficiency. Any changes in foreign exposures has an influence on the technical efficiency.

During the Financial Crisis, the technical efficiency declined. The banks were more reliant on the operations across the border. As a result, they accumulated lots of Foreign Exposures. The changes in the economic conditions in the foreign country contributed towards the bank's inability to convert inputs to outputs. Furthermore, Bad Loans were increasing for the banks. This caused the technical efficiency to decline. During European Debt Crisis, the countries witnessing the European Debt Crisis, they had a decline in their domestic exposures. However, this decline did not influence the technical efficiency. The bank's portfolio included both Domestic and Foreign Exposures. The decline in Domestic Exposures made the bank to rely more on its foreign operations. As a result, the technical efficiency did not suffer. This highlights the role of globalisation played on cross-border banking. Additionally, it highlights the role of the cross-border exposures on the efficiency of the banks.

4.5.3 Honore's Tobit Estimator Results

In the second stage of the analysis, the study employs a Tobit regression model to investigate the role of liquidity shock and cross-border exposures. This is done by using the WRDDM efficiency scores as the dependent variable. In the earlier studies, due to the limited nature of our efficiency measure that ranges between 0 and 1, this study uses an Honore Tobit Estimator rather than OLS. Hausman Test is performed on each model to check the consistency of the results estimated by Honore Tobit Estimator. For each model, the null hypothesis is rejected in the Hausman Test. This show the results with Fixed Effects are consistent. F-test has been used in the study for measuring the significance of the model. The p-value of F-test is less than 5% in all the models. This shows the model is a better fit. Following Pasiouras et al. (2006) and Pasiouras (2008a), QML (Huber/White) standard errors and covariates are calculated. This is because heteroskedasticity can emerge when estimated parameters are used as dependent variables in the second stage analysis.

As a robustness check, the study follows Langfield and Pagano (2016). They compared the results of the fixed effects panel with Honore Tobit estimator. The study follows its methodology and preserves the fixed effects panel set-up. The results for the fixed-effect panel are reported in table C.3 and C.4. The results of tables C.3 and C.4 are found to be consistent with the results obtained in tables 4.9 and 4.10 using Honore's Tobit Estimator.

Controlling for Bank-specific characteristics

Table 4.9 and 4.10 presents the regression results when controlling for the bank-specific characteristics. For the sub-sample with high financial development, LOGTA and EQASS have a significantly positive impact on the technical efficiency of the banks. The findings suggest that by having higher capital, the confidence of depositors in the bank's security. LOANTA and NPL have a significantly negative impact on the technical efficiency of the banks. These findings are consistent with the earlier findings byKwan et al. (1995) and Resti (1997). These results imply that banks must focus on credit risk management. The credit risk management has been a problematic issue in the past. Serious banking problems have arisen from the failure of the banks to recognize impaired assets and create reserves for writing off these assets.Havrylchyk (2006)

Table 4.9: Honore Tobit Estimator results for the banks in countries with higher Financial Development than the average Financial Development of the sample over the period 2005-2019. The dependent variable is Technical Efficiency scores calculated using Weighted Russell Directional Distance Model.Model 1 controls for bank characteristics. Model 2 controls for bank characteristics and Macroeconomic Conditions. Model 3 controls for bank characteristics ,Macroeconomic Conditions and Domestic and Foreign Exposures. Model 4 controls for bank characteristics, Macroeconomic Conditions and Exposures in different regions. QML (Huber/White) standard errors and covariates have been calculated to control for heteroscedacity.The control variables have been standardised. (***Statistically significant at 1% level, **Statistically significant at 5% level, *Statistically significant at 10% level).

VARIABLES	Model 1	Model 2	Model 3	Model 4
LOGTA	0.007***	0.007***	0.008***	0.008***
	(0.002)	(0.002)	(0.003)	(0.002)
NPL	-0.008***	-0.008***	-0.008***	-0.008***
	(0.001)	(0.001)	(0.001)	(0.001)
LOANTA	-0.017**	-0.017**	-0.015**	-0.017**
	(0.007)	(0.007)	(0.006)	(0.007)
EQASS	0.003*	0.003*	0.004	0.002**
	(0.002)	(0.002)	(0.006)	(0.004)
ROE	0.002	0.002	0.003	0.003
	(0.004)	(0.004)	(0.002)	(0.002)
GDPGR		0.006**	0.007**	0.007**
		(0.003)	(0.003)	(0.003)
DEXP			0.005**	0.001***
			(0.002)	(0.004)
FEXP			0.001***	
			(0.001)	
EUROEXP				0.101**
				(0.079)
NAMEXP				0.082**
				(0.076)
SAMEXP				-0.021*
				(0.048)
AFEXP				-0.010***
				(0.007)
ASEXP				-0.023**
				(0.047)
LIQSHOCK	0.002***	0.002***	0.001***	0.001***
	(0.005)	(0.005)	(0.006)	(0.005)
Time Fixed Effects	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes
R-Squared	0.407	0.427	0.577	0.617
Hausman Test	32.88	35.39	44.40	51.21
Observations	18,435	18,435	18,400	18,240

Table 4.10: Honore Tobit Estimator results for the banks in countries with lower Financial Development than the average Financial Development of the sample over the period 2005-2019. The dependent variable is Technical Efficiency scores calculated using Weighted Russell Directional Distance Model.. Model 1 controls for bank characteristics. Model 2 controls for bank characteristics and Macroeconomic Conditions. Model 3 controls for bank characteristics ,Macroeconomic Conditions and Domestic and Foreign Exposures. Model 4 controls for bank characteristics, Macroeconomic Conditions and Exposures in different regions. QML (Huber/White) standard errors and covariates have been calculated to control for heteroscedacity.The control variable have been standardised. (***Statistically significant at 1% level, **Statistically significant at 5% level, *Statistically significant at 10% level).

VARIABLES	Model 1	Model 2	Model 3	Model 4
LOGTA	0.008***	0.008***	0.008***	0.009***
	(0.003)	(0.003)	(0.003)	(0.003)
NPL	-0.005***	-0.005***	-0.005***	-0.005***
	(0.001)	(0.001)	(0.001)	(0.001)
LOANTA	-0.021**	-0.021**	-0.022**	-0.022**
	(0.009)	(0.009)	(0.009)	(0.009)
EQASS	-0.001**	-0.001	-0.002**	-0.002**
	(0.006)	(0.006)	(0.009)	(0.009)
ROE	0.002	-0.002**	0.001	0.001
	(0.002)	(0.002)	(0.001)	(0.001)
GDPGR		0.001*	0.001	0.001*
		(0.002)	(0.002)	(0.002)
DEXP			-0.002	0.015***
			(0.005)	(0.004)
FEXP			0.808***	
			(0.060)	
EUROEXP				0.025
				(0.027)
NAMEXP				0.005
				(0.027)
SAMEXP				0.061***
				(0.017)
AFEXP				0.003**
				(0.005)
ASEXP				0.047***
				(0.016)
LIQSHOCK	0.015**	0.015*	0.015*	0.016*
	(0.009)	(0.009)	(0.009)	(0.009)
Time Fixed Effects	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes
R-Squared	0.526	0.580	0.612	0.653
Hausman Test	29.10	33.42	34.63	42.76
Observations	10,530	10,530	10,500	10,460

found a negative relationship between LOANTA and efficiency. LOANTA is considered as a proxy for Liquidity risk. Therefore, a negative relationship could indicate that less efficient banks are also less liquid. The results indicate that an environment of careful lending contributes to better bank performances. Furthermore, it will be helpful in reducing the likelihood of financial distress faced by the banks Pasiouras et al. (2009). LIQSHOCK is statistically significant and it has a positive impact on the bank inefficiency. This is because Liquidity Shock affects the funding costs of the banks and bank lending (Allen et al.,2011). The loans of the banks facing liquidity shock are priced at higher spreads (Sarmiento, 2018). Furthermore, the banks will be borrowing more liquidity from the interbank markets to overcome the liquidity shock. The banks will rely more on the lending relationships in order to obtain a lower spread for the interbank funds.

In the sub-sample with countries having less Financial Development, EQASS exhibits a negative relationship with technical efficiency and is highly significant. This implies that the more efficient banks in these countries use less equity compared to its peers. Also, it suggests that the less efficient banks could be involved in riskier operations and this process tends to hold more equity, voluntarily or involuntarily, i.e., the reason might be banks' deliberate efforts to increase safety cushions and in turn decrease the cost of funds or perhaps regulatory pressures that mandate riskier banks to carry more equity. The other results are similar to the results of the sample with higher financial development.

For sample with higher financial development, A 1% increase in bank efficiency would require the bank's EQASS to increase by 1.17%. Similiarily, a 1% increase in bank efficiency would require the bank's NPL to reduce by 3.15%. A 1% increase in bank efficiency would require the bank's LOANTA to decrease by 0.79%. A bank not facing the liquidity shock would be increasing its efficiency by 80.73%. However, a bank facing liquidity shock would increase by 19.26%. For a bank facing Liquidity Shock, to increase the efficiency by 1%, the bank will have to increase LOGTA by 1.44%. Similarly, an increase in EQASS by 2.35% will increase the efficiency by 1%. The bank will have to reduce NPL by 5.47% to increase efficiency by 1%. For increasing the bank efficiency by 1%, the bank will have to decrease LOANTA by 1.95%. For a

bank not facing Liquidity Shock, the bank will have to increase LOGTA by 3.21% to improve the efficiency by 1%. An increase in EQASS by 1.83% to grow efficiency by 1%. To raise efficiency by 1%, the bank will have to reduce NPL by 5.13%. For 1% increase in efficiency, the bank has to lessen LOANTA by 1.52%.

For sample with lower financial development, A 1% increase in bank efficiency would require the bank's EQASS to increase by 2.77%. Similiarily, a 1% increase in bank efficiency would require the bank's NPL to reduce by 9.63%. A 1% increase in bank efficiency would require the bank's LOANTA to decrease by 3.57%. A bank not facing the liquidity shock would be increasing its efficiency by 73.36%. However, a bank facing liquidity shock would increase by 26.63%. For a bank facing Liquidity Shock, to increase the efficiency by 1%, the bank will have to increase LOGTA by 3.34%. Similarly, an increase in EQASS by 6.80% will increase the efficiency by 1%. The bank will have to reduce NPL by 5.81% to increase efficiency by 1%. For increasing the bank efficiency by 1%, the bank will have to decrease LOANTA by 5.37%. For a bank not facing Liquidity Shock, the bank will have to increase LOGTA by 1.50% to improve the efficiency by 1%. An increase in EQASS by 3.79% to grow efficiency by 1%. To raise efficiency by 1%, the bank will have to reduce NPL by 4.56%. For 1% increase in efficiency, the bank has to lessen LOANTA by 4.04%.

Controlling for Macroeconomic conditions

Table 4.9 and 4.10 presents the regression result when controlling for the bank characteristics and the macroeconomic conditions. For the banks in countries with higher financial development, the growth of the GDP in the model affects the other bank-specific variables. GDPGR has a significantly positive impact on technical efficiency. This indicates that the favourable economic conditions affect the extent, depth and quality of financial intermediation and banking services. This contributes toward making the financial institutions more efficient. Furthermore, by having a higher growth rate, it would be easier for the debtors to meet their obligations. The other variables having a significant impact on the efficiency are EQASS, LOANTA, NPL and LOGTA.

For sub-sample with countries having lesser Financial Development, the

growth of GDP in the model affects the other bank-specific variables. GDPGR has a significantly positive relation with technical efficiency. This shows the role of favourable economic conditions play on financial intermediation and banking services. ROE is having a negatively significant impact on the efficiency of the banks. This suggests that a more profitable bank would have lower inefficiency. This corroborates with similar findings of the other studies (Pastor et al., 1997; Das and Ghosh, 2006). Usually, the clients prefer the banks, which report higher profitability ratios. These banks attract the biggest share of deposits along with the best potential creditworthy borrowers. Moreover, this also implies that the banks may have higher ROE by either having higher leverage (debt) or higher risk-taking. The other variables having a significant impact on the efficiency are LOGTA, NPL and LOANTA.

For banks in higher financial development, An increase in GDPGR by 0.80% would contribute towards 1% increase in the efficiency of the bank. For banks in lower financial development, An increase in GDPGR by 1.32% would contribute towards 1% increase in the efficiency of the bank. This reflects the significance of the real GDP growth towards bank efficiency. The growth in GDP reflects the growth in the economy. As a result, the role of favourable economic conditions towards bank efficiency is significant (Chortareas et al., 2011). This would be making the bank more efficient.

Controlling for Domestic and Foreign Exposures

Table 4.9 and 4.10 presents the regression results when controlling for the bank characteristics, macroeconomic conditions, domestic exposures and foreign exposures. For banks located in the countries with higher financial development, the results indicate DEXP and FEXP having a significant impact on the technical efficiency of the banks. The banks are looking for different asset portfolios, which would be generating better returns and requires different resources to be managed. The favourable economic conditions in the country where the bank invests are very important. This allows the bank to become more efficient. As the bank is looking to be engaged in activities that are more profitable. With the bank located in a higher financial developed country, the bank has greater depth (size and liquidity of markets), access (the ability of individuals and companies to access financial services), and efficiency (the ability of insti-

tutions to provide financial services at low cost and with sustainable revenues, and the level of activity of capital markets) (Svirydzenka, 2016). This affects the quality of financial intermediation and banking services. As a result, this helps banks becoming more efficient. The foreign exposures may influence the bank in excessive risk-taking activities. This shows how the dynamics of the banking sector has changed over the years. The banks have become more involved in managing their activities and not limiting their activities to their located country. Furthermore, it reflects the growth in foreign nations in more than the host country. This may be one of the factors influencing the banks to increase their foreign exposures. The results indicate that the bank performance in the host nation is a good safeguard against cross-border competition due to the differences in available technology and environmental conditions (Lozano-Vivas and Pastor, 2010). The other variables having a significant impact on the efficiency are LOGTA, NPL, LOANTA and GDPGR.

For banks located in the countries with lower financial development, the results indicate FEXP has a highly significant impact on the technical efficiency of the banks. Foreign Exposures allows the bank to diversify its portfolio. This results in generating better returns and managing different resources. The bank invests in foreign countries. The investment presents the bank an opportunity to engage in more activities that are profitable. Usually, the growth in foreign nations is more than the host country. As a result, the favourable economic conditions in the foreign nation contributes to generating better returns for the bank. Also, it influences the bank to increases its foreign exposures. Additionally, it contributes to increasing the technical efficiency of the bank. DEXP is not significant on the technical efficiency of the bank. The results indicate the role of the differences in the bank regulations plays a significant role in the capital flows and technical efficiency of the banks. The banking regulations in the lower financial developed country prevent the opportunities for the banks required for its growth (Houston et al., 2012). As a result, the bank invests abroad because it presents a better opportunity to increase its returns. The other variables having a significant impact on the efficiency are LOGTA, NPL, LOANTA AND EQASS.

For the bank in higher financial development, to increase the bank efficiency by 1%, a bank would be required to increase its FEXP by 3.47%. DEXP

increase by 0.82% contributes towards a 1% increase in bank efficiency. A bank facing liquidity shock would increase its efficiency by 1% by increasing its DEXP by 0.66%. Similarly, an increase in FEXP by 0.73% increase the efficiency by 1%. A bank not facing liquidity shock would increase the efficiency by 1% by increasing its FEXP by 0.60%. A 1% increase in the bank efficiency for the bank not facing liquidity shock would be contributed by an increase in FEXP by 0.65%.

For the bank in lower financial development, to increase the bank efficiency by 1%, a bank would be required to increase its FEXP by 0.50%. DEXP decreases by 0.66% contribute toward a 1% increase in bank efficiency. A bank facing liquidity shock would increase its efficiency by 1% by decreasing its DEXP by 0.86%. Similarly, an increase in FEXP by 0.83% increase the efficiency by 1%. A bank not facing liquidity shock would increase the efficiency by 1% by decreasing its DEXP by 0.35%. A 1% increase in the bank efficiency for the bank not facing liquidity shock would be contributed by an increase in FEXP by 0.56%.

Controlling for Domestic Exposures and Cross-Border Exposures

Table 4.9 and 4.10 presents the regression results when controlling for the bank characteristics, macroeconomic conditions and exposures from different regions. For the banks located in countries with higher financial development, the results indicate that the exposures from different regions are highly significant. DEXP, EUROEXP and NAMEXP have a significantly positive relation with technical efficiency. SAMEXP, AFEXP and ASEXP have a significantly negative relation with technical efficiency. The exposures show the significance of financial development in these regions. The regions with higher financial development have a positive relation with the technical efficiency of the banks. The regions with lower financial development have a negative relation with technical efficiency. The financial development affects depth, access and efficiency of the bank. By investing in a country with higher financial development, the bank is able to generate better returns and manage its resources more efficiently. This is because the bank is more familiar with the operations in a higher financial developed country. Additionally, these results indicate the role of the property rights, legal inefficiencies or a high risk of expro-

priation have on the decision-making of the banks (Papaionnouc,2009). The exposures reflect the economic conditions in those countries. The favourable economic conditions have a significant role in the economy and the banking sector. The banks will be looking for different asset portfolios, which will be generating better returns and requires the different resources to be managed. The favourable economic conditions in the region would be making the bank more efficient. The bank would be looking to getting engaged in more profitable activities. Furthermore, these activities would be making the balance sheet of the bank's inclined more towards the exposures with regions having favourable economic conditions. The geographical diversification has a significant role on the technical efficiency of the banks. The banks will be investing in the regions with conditions that are more similar to their home country. The other variables having a positive relation and are significant are EQASS, LOGTA and GDPGR. LOANTA and NPL have a significantly negative relation with efficiency.

For banks located in the countries with lower financial development, the results show DEXP, SAMEXP, AFEXP and ASEXP have a significantly positive impact on the technical efficiency of the banks. The portfolio of the bank consists of different assets which allow them to generate better returns and manage different resources. The bank invests more in the regions which have financial development similar to the country where the bank is located. This allows the bank to manage its resources more efficiently and generate better returns. By investing in regions with similar financial development conditions, the banks are able to manage their operations effectively. Technological development plays an important role as well. In countries with similar technological advancement, the bank is more efficient in setting up their products (Baumol, 1986). The other variables have a significant impact on the technical efficiency are LOGTA, NPL, LOANTA, EQASS and GDPGR.

For the banks in countries with higher Financial Development, For the bank facing Liquidity Shock, to increase the efficiency by 1%, the bank would have to increase DEXP by 2.86%. Similarly, the bank would have to increase EUROEXP and NAMEEXP by 3.86% and 2.28% to increase the bank efficiency by 1% respectively. To increase the bank efficiency 1%, the bank would have to reduce SAMEXP by 9.6%. Similarly, it would have to reduce AFEXP by

5.06% to increase efficiency by 1%. For the bank not facing Liquidity Shock, to increase the efficiency by 1%, the bank would have to increase DEXP by 1.09%. Similarly, the bank would have to increase EUROEXP and NAMEEXP by 2.09% and 1.71% to increase the bank efficiency by 1% respectively. To increase the bank efficiency 1%, the bank would have to reduce SAMEXP by 7.49%. Similarly, it would have to reduce AFEXP and ASEXP by 6.43% and 3.58% to increase efficiency by 1%.

For the banks in countries with lower Financial Development, For the bank facing Liquidity Shock, to increase the efficiency by 1%, the bank would have to increase DEXP by 3.02%. Similarly, the bank would have to decrease EUROEXP and NAMEEXP by 6.76% and 5.44% to increase the bank efficiency by 1% respectively. To increase the bank efficiency 1%, the bank would have to increase SAMEXP by 7.93%. Similarly, it would have to increase AFEXP and ASEXP by 2.07% and 1.14% to increase the efficiency by 1%. For the bank not facing Liquidity Shock, to increase the efficiency by 1%, the bank would have to decrease DEXP by 1.11%. Similarly, the bank would have to decrease EUROEXP and NAMEEXP by 2.04% and 0.92% to increase the bank efficiency by 1% respectively. To increase the bank efficiency 1%, the bank would have to reduce SAMEXP by 3.28%. Similarly, it would have to reduce AFEXP and ASEXP by 5.10% and 2.87% to increase efficiency by 1%.

4.6 Conclusion

The study employs Weighted Russell Direction Distance Model and Tobit regression to examine the role of cross-border exposures with liquidity shock on the technical efficiency of the bank in relation to financial development. The sample consists of 1931 banks operating in 15 European countries for the period 2005-2019. The study employs a Financial Development indicator to divide the sample into 2 sub-sample. With sub-sample with high development has 1229 banks in 8 European countries and with lower financial development has 702 banks in 7 European countries.

The results indicate that the average technical efficiency of the banks in the country with high financial development is 0.19. The average bank in the sample could improve its technical efficiency by 81%. The average tech-

nical efficiency of the banks in the country with low financial development is 0.183. The average bank in the sample could improve its technical efficiency by 81.7%. Financial development difference between the sample is 0.054. However, a major difference appeared by looking at individual countries in the two sample. The most financially developed country in the sample was Germany could improve its technical efficiency by 80.8%. The least financially developed country in the sample was Spain. The average technical efficiency of the banks in Spain is 0.230. This means that it could improve its technical efficiency by 77%. The average technical efficiency of the banks in Spain witnessed many fluctuations. On average, the technical efficiency of the banks declined after the Global Financial Crisis. The changes in the technical efficiency of the banks facing liquidity shocks are more unstable. The technical efficiency of the banks facing Liquidity Shocks is much lower during the Global Financial Crisis. The technical efficiency of the banks not facing liquidity shock is more similar to the average technical efficiency of the banks. The decline in the cross-border exposures was a witness with a decline in efficiency. But, the decline was minimum in the domestic exposures. This reflects the significance of the cross-border exposures on the efficiency of the banks.

Following Weighted Russell Directional Distance model's result, Honore's Tobit estimator is used while controlling for bank characteristics, liquidity shock, macroeconomic conditions, domestic exposures and cross-border exposures. In the sample with high financial development, when controlling for bank characteristics and liquidity shock, Size and Capital have a significantly positive impact on the efficiency. Loan Activity and Asset Quality have a significantly negative impact on efficiency. Liquidity Shock has a significantly positive relation with the inefficiency. Liquidity Shocks affects the funding costs of the bank and bank lending. The loans of the banks facing liquidity shock are priced at the higher spread. This reveals the significance of the liquidity shock on the technical efficiency of the banks. The results are similar for the sample with lower financial development.

In the sample with high financial development, when controlling for the bank characteristics, liquidity shock and macroeconomic conditions, the results show that real GDP growth has a significantly positive relation with the technical efficiency of the bank. As the economy grows, the debtors would be

able to meet their obligations. Capital and Size have a significantly positive relation with efficiency. Loan Activity and Asset Quality have a significantly negative impact on the efficiency of the banks. The results for lower financial development countries show that real GDP growth has a significantly positive impact on efficiency. Size has a significantly positive impact on efficiency. Asset Quality, Loan Activity and Profitability have a significantly negative impact on the efficiency of the banks.

When controlling for the bank characteristics, liquidity shock, macroeconomic conditions, domestic exposures and foreign exposures, the results indicate the relation between the foreign exposures, the technical efficiency of the banks is positive and highly significant for both the sample. However, Domestic Exposures has a significantly positive impact on the efficiency for the sample with high financial development. This reveals the significance of financial integration and globalisation in the banking sector. The banks are looking for different asset portfolios, which would be generating better returns and requires different resources to be managed. The banks have become more involved in managing their activities and not limiting their activities to their located country. For the sample with high financial development, the other variables such as Size and real GDP growth have a significantly positive impact on efficiency. Loan Activity and Asset Quality have a negative relation with the technical efficiency of the banks and are highly significant. For sample with lower financial development, Size has a significantly positive impact on efficiency. Loan Activity, Asset Quality and Capital have a significantly negative impact on efficiency.

When controlling for the bank characteristics, liquidity shock, macroeconomic conditions, domestic exposures and foreign exposures from different regions, the results indicate foreign exposures from different regions have significant impact on the efficiency of the banks. For the banks in countries with high financial development, Domestic Exposures, Europe Exposures and North America Exposures have a significantly positive impact on efficiency. South America Exposures, Africa Exposures and Asia Exposures have a significantly negative impact on efficiency. For the banks in countries with low financial development, Domestic Exposures, South America Exposures, Africa Exposures and Asia Exposures have a significantly positive impact on the efficiency. The

exposures from other regions to do not have a significant impact on efficiency. The results show the role of financial integration and globalisation plays in the banking sector. For the banks to improve their efficiency, they would be better by investing in the countries with a similar level of financial development. This would allow them to have better returns and improve their daily operations.

The results of the study are significant for the policymakers and the banks. Most of the banks have increased cross-border exposures over the years. The financial integration has fostered cross-border banking. Cross-border banking provides the banks with an opportunity of diversification. The diversification is risk-reducing. With favourable economic conditions in the foreign country, the bank would be more inclined towards increasing their cross-border exposures. Moreover, investing in a foreign country with a similar level of financial development allows the bank to improve and have better returns. It allows the bank to manage their resources better. The cross-border exposures from favourable country contribute towards an increase in the efficiency of the banks. The bank facing liquidity shock would be reducing the cross-border exposures from regions with less favourable economic conditions. The barriers to cross-border banking would discourage the banks towards cross-border activities. These barriers may be in terms of the financial development of a foreign country. This may have a negative impact on the efficiency of the banks.

Chapter 5

Conclusion

This thesis bundles three empirical chapters in the area of efficiency in banking. These studies investigate the role of banking reforms or shocks on bank efficiency. This chapter begins with a summary of the key findings and contributions and then finishes with the remarks and suggestions for future work.

5.1 Key findings and Contribution

In Chapter 2, we investigate the role of EBA's capital exercise on the technical efficiency of the banks. We find that the average bank in the sample could improve its technical efficiency by 52.47%. But, before the announcement, it was 50.6%. The results indicate that the capital exercise has contributed toward a slight increase in the average bank in the sample for improving its technical efficiency. Following the Bootstrap DEA results, the Double Bootstrap model is used while controlling for the bank-specific characteristics and country-level characteristics accounting for macroeconomic conditions, financial development, and market structure. The capital exercise announcement has led to change in the bank-specific characteristics which determine the technical efficiency of the bank.

For the bank-level analysis, the average efficiency of the capital exercise banks has been lower than the non-capital exercise banks. After the Capital Exercise, the capital exercise banks had a drop in their efficiency from 2011 to 2014. This has been because of the impact of the capital exercise as these banks had to adjust their balance sheets according to the new capital requirements. The results indicate the bank characteristics have a significant impact

on the technical efficiency of the banks. EBA capital announcement has made the banks consider their activity in the banking sector and to manage their portfolios. As a result, the banks would be having less likelihood of having financial distress. EBA has looked to prevent the banks from potential systemic risk. EBA's capital announcement has contributed towards the banks getting involved in careful lending practices, which would be improving the overall performance and soundness of the banks.

The stricter capital regulations by EBA would only be improving the efficiency of the banks if the regulatory screening ability is low. When the capital regulations are placed, the banks are looking to substitute the loans with alternative forms of assets. The banks are looking for different asset portfolios which would be generating better returns and requires the different resources to be managed. The results indicate that the capital requirement by the EBA which came as a shock for the banks would be contributing towards making the banks more stable. It would be preventing banks from excessive risk-taking activities. Furthermore, it would be allowing the banks to withstand financial distress. Although, the capital requirements would not be a highly significant benefit for the efficiency gains. But, it would be creating favourable economic conditions which would affect the extent, depth, and quality of financial intermediation and banking services.

Chapter 3 explores the role of different risk measures on the cost efficiency of the banks. Heteroscedastic stochastic frontier model is used to investigate the effect of each risk measure on the mean and variance of the cost efficiency. The results show that each risk measure presents a similar effect on the cost efficiency of the banks. Funding Liquidity Risk has a positive effect on the mean and the variance on the inefficiency effect. Liquidity Risk has a significantly positive effect on the inefficiency effect. Additionally, NPEs have a significantly positive effect on the mean and variance of the inefficiency effect. Furthermore, there are non-linear effects of some of the risk factors such as Funding Liquidity Risk and NPEs on the mean and variance of the inefficiency effect. However, for Liquidity Risk, the marginal effects indicate a non-monotonic effect.

The effects of the risk measures are not consistent over time. In 2011, the marginal effect of Funding Liquidity Risk on the mean is very high. After 2011,

the effect starts declining until 2016. However, from 2017 onwards, the effect has again started increasing. The marginal effect shows the negative effect on cost efficiency. The marginal effect on variance has both a negative and positive effect on cost efficiency over the years. For Non-Performing Exposures, The marginal effect on mean has a positive effect on the cost efficiency and the marginal effect on variance shows inverse U-shape like pattern. For Liquidity Risk, the marginal effect on mean shows U-shape pattern and on variance has a negative effect on the cost efficiency.

In this chapter, the marginal effects of how these risk measures affect both the level and variability of the inefficiency effect across the regions have been investigated. For Funding Liquidity Risk, the marginal effects on the mean of the inefficiency effect of the banks in Asia-Pacific, Latin America and the Caribbean , Middle East, and the United States and Canada show a non-monotonic pattern. The marginal effects on variability of the inefficiency effect for Latin America, the Middle East, and the United States and Canada reveal a non-monotonic pattern. In these regions, the banks in the lowest group have a negative variability in the lowest group and turn positive in the middle and highest groups. For Liquidity Risk, The marginal effects on the mean in Europe show a non-monotonic pattern. It shows a negative inefficiency effect on the low and middle groups whereas a positive inefficiency effect on the highest group. The marginal effects on the variability across the groups in Europe are positive and show a monotonic effect. This reveals that cost efficiency is more varied among the banks in Europe. For Non-Performing Exposures, marginal effects on the mean of the inefficiency effect across all the regions reveal a positive inefficiency effect. On average across the groups, Latin America and the Caribbean has the highest positive inefficiency impact. The marginal effects on variability on the inefficiency effect increase as we move along the groups. The lowest group has the lowest variability, this increase as we move to middle and highest groups.

The recent crisis showed how having inconsistent international standards for categorising problem loans and funding liquidity proved to be a major problem for the banks.The results will be useful for the regulators and policymakers.As the changes in the risk measures in a region impacts on the cost of the efficiency of the bank.Furthermore,the risk measures have a monotonic

effect across different regions.The results will be useful for the regulators and policymakers.These results will help in shaping new regulations which will be preventing the bank from excessive risk-taking.Additionally,the results show how the the risk measures impacts the cost efficiency.

Chapter 4 examines the role of cross-border exposures with liquidity shock on the technical efficiency of the bank in relation to financial development. Financial Development indicator is used to divide the sample into 2 sub-sample. The results indicate that the average technical efficiency of the banks in the country with high financial development is 0.19. The average technical efficiency of the banks in the country with low financial development is 0.183. Financial development difference between the sample is 0.054. The changes in the technical efficiency of the banks facing liquidity shocks are more unstable. The technical efficiency of the banks facing Liquidity Shocks is much lower during the Global Financial Crisis. The technical efficiency of the banks not facing liquidity shock is more similar to the average technical efficiency of the banks. The decline in the cross-border exposures was a witness with a decline in efficiency. But, the decline was minimum in the domestic exposures. This reflects the significance of the cross-border exposures on the efficiency of the banks.

Domestic Exposures have a significantly positive impact on the efficiency for the sample with high financial development. This reveals the significance of financial integration and globalisation in the banking sector. The banks are looking for different asset portfolios, which would be generating better returns and requires different resources to be managed. The banks have become more involved in managing their activities and not limiting their activities to their located country. Furthermore, When controlling for the bank characteristics, liquidity shock, macroeconomic conditions, domestic exposures, and foreign exposures from different regions, the results indicate foreign exposures from different regions have a significant impact on the efficiency of the banks. For the banks in countries with high financial development, Domestic Exposures, Europe Exposures, and North America Exposures have a significantly positive impact on efficiency. South America Exposures, Africa Exposures, and Asia Exposures have a significantly negative impact on efficiency. For the banks in countries with low financial development, Domestic Exposures, South America

Exposures, Africa Exposures, and Asia Exposures have a significantly positive impact on the efficiency. The exposures from other regions do not have a significant impact on efficiency. The results show the role of financial integration and globalisation plays in the banking sector. For the banks to improve their efficiency, they would be better by investing in countries with a similar level of financial development. This would allow them to have better returns and improve their daily operations.

The results of the study are significant for the policymakers and the banks.Over the years,the financial integration has increased cross-border banking.Cross-border banking provides the banks with an opportunity of diversification.As a result,cross-border exposures has increased.Cross-border banking provides an opportunity for diversification.Diversification is helpful in risk reduction.With favourable economic conditions in the foreign country, the bank would be more inclined towards increasing their cross-border exposures. Moreover, investing in a foreign country with a similar level of financial development allows the bank to improve and have better returns. It allows the bank to manage their resources better. The cross-border exposures from favourable country contribute towards an increase in the efficiency of the banks. The bank facing liquidity shock would be reducing the cross-border exposures from regions with less favourable economic conditions. The barriers to cross-border banking would discourage the banks towards cross-border activities. These barriers may be in terms of the financial development of a foreign country. This may have a negative impact on the efficiency of the banks.

5.2 Concluding remarks and suggestions for the future work

This thesis sheds light on the role of banking reforms or shocks on bank efficiency. However, it is still possible to further strengthen the empirical evidence following this thesis.

Chapter 2 focuses on the role of EBA's capital exercise on the technical efficiency of the banks. For a possible future extension of this research, it would be interesting to investigate whether the change in technical efficiency is something that was particular to this increase in the capital requirements.

Also, to investigate the role of the capital exercise on the profit and cost efficiency of the banks. As the stricter capital requirements reduce the likelihood of financial distress but, the profits may decline. Further research is required on the role of the post-crisis capital and liquidity requirement on the technical efficiency of the banks.

Chapter 3 focuses on the role of different risk measures on the cost efficiency of the banks. Future work could include other risk measures such as market risk and operational risk to provide a comprehensive analysis. Also, it would be interesting to further examine the role of different risk measures on the cost efficiency in individual countries. It would be also worthwhile to extend the analysis by taking financial development into consideration.

Chapter 4 examines the role of cross-border exposures with liquidity shock on the technical efficiency of the bank in relation to financial development. It would also be enlightening to consider the role of cross-border exposures with liquidity shock on the profit and cost efficiency of the banks. For further extension of this research, it would be interesting to include the cross-border exposures from individual countries.

This thesis provides an analysis of the role of banking reforms or shocks on bank efficiency. Chapter 2 highlights the role of the capital exercise requirement on the technical efficiency of the banks and how the bank characteristics and environmental variables play a role on efficiency. Chapter 3 provides an analysis of different risk measures such as NPEs and Funding Liquidity Risk on cost efficiency. Chapter 4 highlights the role of cross-border exposures with liquidity shock on the technical efficiency of the bank in relation to financial development. These findings would be of interest to regulators, policymakers, and banks. Globalisation has increased the activities of the banks. The banks are managing different portfolios in order to maximise the returns. These findings will help in making better regulations for the banks. Further, it would be helping in making them more efficient in conducting their business.

Appendices

Appendix A

Chapter 2

Table A.1: Correlation of Inputs and Outputs variables used in Boostrap DEA.Input variables are Deposits,Equity,Interest Expenses and Non-Interest Expenses.Output variables are Loans,Non-Interest Income and Other Earning Assets.The inputs and outputs variables are used in DEA for calculating efficiency scores.The sample period is 2008-2015.The sample consists of 194 banks for each year.(* statistically significant at 1% level)

	Deposits	**Equity**	**Int. Expenses**	**Non-Int. Expense**	**Loans**	**Non-Int.Income**	**OEA**
Deposits	1						
Equity	0.969*	1					
Int.Expenses	0.633*	0.563*	1				
Non-Int.Expense	0.921*	0.895*	0.700*	1			
Loans	0.957*	0.930*	0.728*	0.901*	1		
Non-Int.Income	0.859*	0.843*	0.634*	0.962*	0.828*	1	
OEA	0.900*	0.897*	0.587*	0.891*	0.844*	0.848*	1

Table A.2: Correlation of the control variables used in Double Bootstrap Truncated regression model.The sample period is 2008-2015.The sample consists of 194 banks for each year.(* statistically significant at 1% level)

	LOGTA	**EQASS**	**LOANTA**	**NPL**	**ROE**	**CLAIMS**	**ASSGDP**	**CONC**	**GDPGR**
LOGTA	1								
EQASS	-0.181*	1							
LOANTA	-0.216*	-0.164							
NPL	-0.118	-0.034	0.080	1					
ROE	-0.023	0.073	-0.006	-0.097	1				
CLAIMS	0.215*	-0.123	0.000	-0.031	-0.024	1			
ASSGDP	0.030	-0.025	-0.229*	-0.103	-0.010	0.056	1		
CONC	0.049	-0.170	0.046	0.085	0.046	0.503*	-0.231*	1	
GDPGR	0.120	0.015	-0.272*	-0.199*	-0.086	0.004	0.282*	-0.174*	1

Table A.3: Correlation of Inputs and Outputs variables used in Bootstrap DEA before the Capital Exercise.Input variables are Deposits,Equity,Interest Expenses and Non-Interest Expenses.Output variables are Loans,Non-Interest Income and Other Earning Assets.The inputs and outputs variables are used in Bootstrap DEA for calculating efficiency scores.The sample period is 2008-2011.The sample consists of 194 banks for each year.(* statistically significant at 1% level)

	Deposits	**Equity**	**Int.Expenses**	**Non-Int. Expenses**	**Loans**	**Non-Int.Income**	**OEA**
Deposits	1						
Equity	0.952*	1					
Int. Expenses	0.949*	0.929*	1				
Non-Int. Expense	0.958*	0.925*	0.915*	1			
Loans	0.985*	0.967*	0.961*	0.944*	1		
Non-Int.Income	0.869*	0.841*	0.809*	0.895*	0.8514	1	
OEA	0.894*	0.894*	0.886*	0.855*	0.915*	0.774*	1

Table A.4: Correlation of Inputs and Outputs variables used in Bootstrap DEA after the Capital Exercise.Input variables are Deposits,Equity,Interest Expenses and Non-Interest Expenses.Output variables are Loans,Non-Interest Income and Other Earning Assets.The inputs and outputs variables are used in Bootstrap DEA for calculating efficiency scores.The sample period is 2012-2015.The sample consists of 194 banks for each year.(* statistically significant at 1% level)

	Deposits	**Equity**	**Int. Expenses**	**Non-Int. Expense**	**Loans**	**Non-Int.Income**	**OEA**
Deposits	1						
Equity	0.977*	1					
Int. Expenses	0.745*	0.703*	1				
Non-Int. Expense	0.956*	0.958*	0.700*	1			
Loans	0.966*	0.942*	0.818*	0.926*	1		
Non-Int.Income	0.911*	0.927*	0.662*	0.972*	0.875*	1	
OEA	0.909*	0.925*	0.660*	0.962*	0.861*	0.949*	1

Figure A.1: Density of Technical Efficiency before the Capital Exercise.The sample period is 2008-2011.The sample consists of 194 banks for each year.The efficiency scores are calculated using Bootstrap DEA.

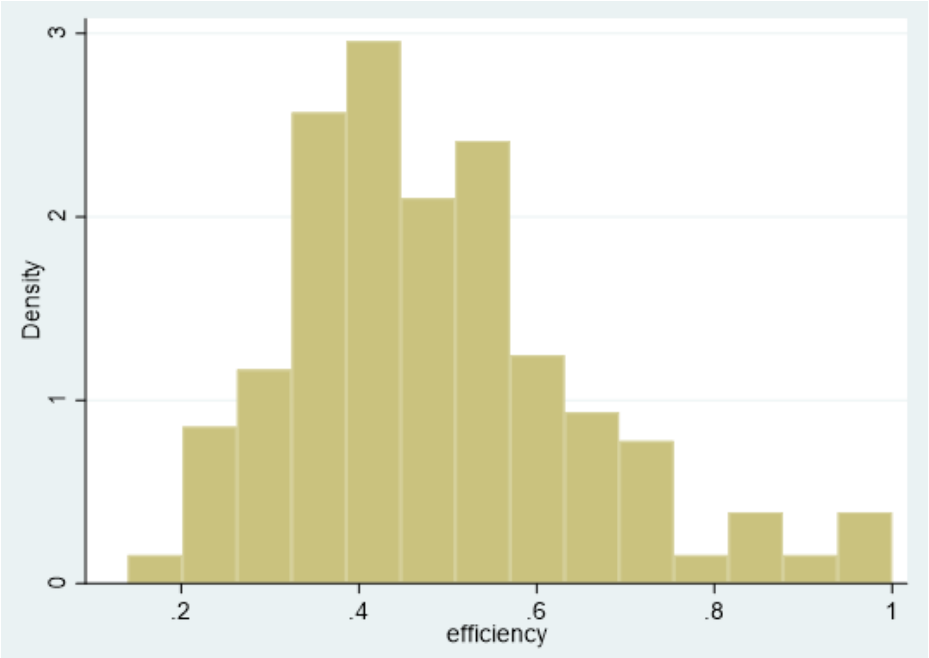


Figure A.2: Density of Technical Efficiency after the Capital Exercise.The sample period is 2012-2015.The sample consists of 194 banks for each year.The efficiency scores are calculated using Bootstrap DEA.

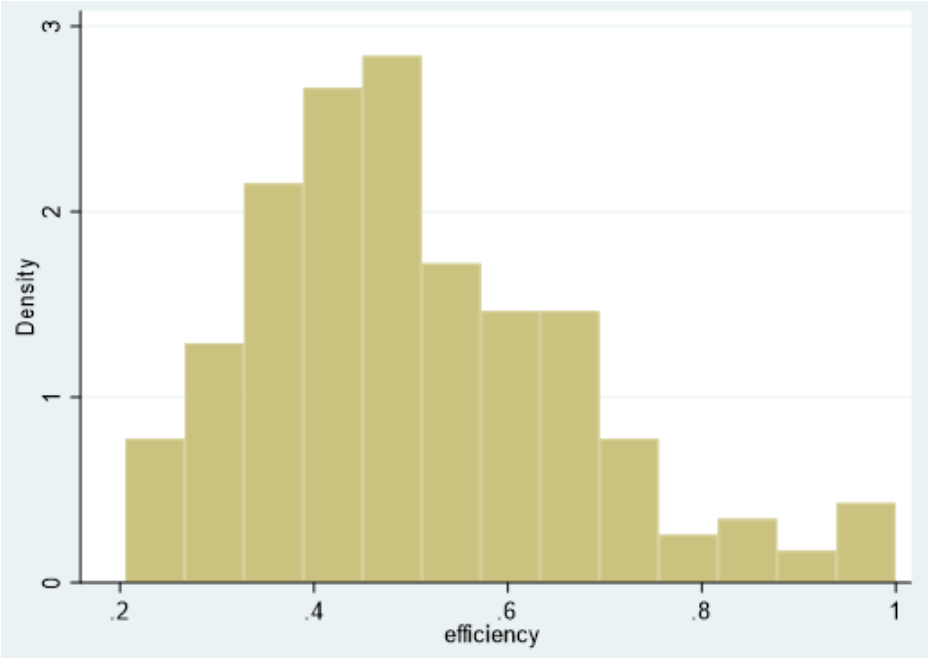


Table A.5: Correlation of the control variables used in Double Bootstrap Truncated regression model before the Capital Exercise.The sample period is 2008-2011.The sample consists of 194 banks for each year.(* statistically significant at 1% level)

	LOGTA	**EQASS**	**LOANTA**	**NPL**	**ROE**	**CLAIMS**	**ASSGDP**	**CONC**	**GDPGR**
LOGTA	1								
EQASS	-0.207*	1							
LOANTA	-0.201*	-0.157	1						
NPL	-0.176	-0.030	0.089	1					
ROE	-0.018	0.074	-0.009	-0.059	1				
CLAIMS	0.234*	-0.120	-0.004	-0.041	-0.025	1			
ASSGDP	0.021	-0.028	-0.228*	-0.068	-0.013	0.058	1		
CONC	0.122	-0.159	0.019	0.105	0.042	0.510*	-0.229*	1	
GDPGR	0.032	-0.009	-0.253*	-0.219*	-0.084	0.020	0.288*	-0.092	1

Table A.6: Correlation of the control variables used in Double Bootstrap Truncated regression model after the Capital Exercise.The sample period is 2012-2015.The sample consists of 194 banks for each year.(* statistically significant at 1% level)

	LOGTA	**EQASS**	**LOANTA**	**NPL**	**ROE**	**CLAIMS**	**ASSGDP**	**CONC**	**GDPGR**
LOGTA	1								
EQASS	-0.323*	1							
LOANTA	-0.111	-0.032	1						
NPL	0.238*	-0.040	-0.027	1					
ROE	0.002	0.026	-0.099	-0.018	1				
CLAIMS	0.204*	-0.282*	0.090	0.095	0.086	1			
ASSGDP	0.037	-0.019	-0.118	-0.100	0.035	0.073	1		
CONC	0.038	-0.312*	0.067	0.092	-0.089	0.461*	-0.208*	1	
GDPGR	0.087	0.091	-0.234*	-0.039	0.040	-0.069	0.289*	0.171	1

Table A.7: Correlation of Inputs and Outputs variables for Non-CEB before the Capital Exercise.Input variables are Deposits,Equity,Interest Expenses and Non-Interest Expenses.Output variables are Loans,Non-Interest Income and Other Earning Assets.The inputs and outputs variables are used in Bootstrap DEA for calculating efficiency scores.The sample period is 2008-2011.The sample consists of 148 banks for each year.(* statistically significant at 1% level).

	Deposits	**Equity**	**Int. Expenses**	**Non-Int. Expense**	**Loans**	**Non-Int.Income**	**OEA**
Deposits	1						
Equity	0.941*	1					
Int. Expenses	0.577*	0.600*	1				
Non-Int. Expense	0.932*	0.978*	0.590*	1			
Loans	0.073*	0.016*	0.163*	0.029*	1		
Non-Int.Income	0.843*	0.910*	0.475*	0.945*	0.037*	1	
OEA	0.877*	0.952*	0.752*	0.953*	0.018*	0.857*	1

Table A.8: Correlation of Inputs and Outputs variables for CEB before the Capital Exercise.Input variables are Deposits,Equity,Interest Expenses and Non-Interest Expenses.Output variables are Loans,Non-Interest Income and Other Earning Assets.The inputs and outputs variables are used in Bootstrap DEA for calculating efficiency scores.The sample period is 2008-2011.The sample consists of 46 banks for each year.(* statistically significant at 1% level).

	Deposits	**Equity**	**Int. Expenses**	**Non-Int. Expense**	**Loans**	**Non-Int.Income**	**OEA**
Deposits	1						
Equity	0.986*	1					
Int. Expenses	0.984*	0.953*	1				
Non-Int. Expense	0.999*	0.989*	0.981*	1			
Loans	0.333*	0.311*	0.345*	0.338*	1		
Non-Int.Income	0.999*	0.990*	0.981*	0.999*	0.328*	1	
OEA	0.997*	0.979*	0.991*	0.996*	0.354*	0.997*	1

Table A.9: Correlation of Inputs and Outputs variables for Non-CEB after the Capital Exercise.Input variables are Deposits,Equity,Interest Expenses and Non-Interest Expenses.Output variables are Loans,Non-Interest Income and Other Earning Assets.The inputs and outputs variables are used in Bootstrap DEA for calculating efficiency scores.The sample period is 2012-2015.The sample consists of 148 banks for each year.(* statistically significant at 1% level).

	Deposits	**Equity**	**Int. Expenses**	**Non-Int. Expense**	**Loans**	**Non-Int.Income**	**OEA**
Deposits	1						
Equity	0.638*	1					
Int. Expenses	0.842*	0.639*	1				
Non-Int. Expense	0.689*	0.962*	0.727*	1			
Loans	0.102*	0.355*	0.165*	0.384*	1		
Non-Int.Income	0.611*	0.827*	0.487*	0.762*	0.141*	1	
OEA	0.891*	0.830*	0.863*	0.884*	0.253*	0.690*	1

Table A.10: Correlation of Inputs and Outputs variables for CEB after the Capital Exercise.Input variables are Deposits,Equity,Interest Expenses and Non-Interest Expenses.Output variables are Loans,Non-Interest Income and Other Earning Assets.The inputs and outputs variables are used in Bootstrap DEA for calculating efficiency scores.The sample period is 2012-2015.The sample consists of 46 banks for each year.(* statistically significant at 1% level).

	Deposits	**Equity**	**Int. Expenses**	**Non-Int. Expense**	**Loans**	**Non-Int.Income**	**OEA**
Deposits	1						
Equity	0.970*	1					
Int. Expenses	0.216*	0.026*	1				
Non-Int. Expense	0.992*	0.953*	0.290*	1			
Loans	0.245*	0.321*	0.138*	0.245*	1		
Non-Int.Income	0.822*	0.909*	0.357*	0.785*	0.334*	1	
OEA	0.977*	0.903*	0.380*	0.986*	0.172*	0.716*	1

Table A.11: Correlation of the control variables used in the Double Bootstrap Truncated regression model before the Capital Exercise for Non-CEB.The sample period is 2008-2011.The sample consists of 148 banks for each year.(* statistically significant at 1% level).

Non-CEB	**ROE**	**NPL**	**LOGTA**	**EQASS**	**LOANTA**
ROE	1				
NPL	0.055	1			
LOGTA	-0.077	-0.187*	1		
EQASS	0.155*	0.006	-0.250*	1	
LOANTA	-0.051	0.184*	-0.244*	0.113	1

Table A.12: Correlation of the control variables used in the Double Bootstrap Truncated regression model before the Capital Exercise for CEB.The sample period is 2008-2011.The sample consists of 46 banks for each year.(* statistically significant at 1% level).

CEB	**ROE**	**NPL**	**LOGTA**	**EQASS**	**LOANTA**
ROE	1				
NPL	0.021	1			
LOGTA	0.251	-0.000	1		
EQASS	0.002	-0.296	-0.236	1	
LOANTA	-0.171	-0.222	-0.399	0.569*	1

Table A.13: Correlation of the control variables used in the Double Bootstrap Truncated regression model after the Capital Exercise for Non-CEB.The sample period is 2012-2015.The sample consists of 46 banks for each year.(* statistically significant at 1% level).

Non-CEB	**ROE**	**NPL**	**LOGTA**	**EQASS**	**LOANTA**
ROE	1				
NPL	0.011	1			
LOGTA	0.087	0.348*	1		
EQASS	-0.076	-0.366*	-0.067	1	
LOANTA	-0.009	-0.288*	-0.241*	0.437*	1

Table A.14: Correlation of the control variables used in the Double Bootstrap Truncated regression model after the Capital Exercise for CEB.The sample period is 2012-2015.The sample consists of 46 banks for each year.(* statistically significant at 1% level).

CEB	**ROE**	**NPL**	**LOGTA**	**EQASS**	**LOANTA**
ROE	1				
NPL	0.402	1			
LOGTA	0.343	0.311	1		
EQASS	0.108	0.241	0.006	1	
LOANTA	-0.552*	-0.103	-0.577*	0.601*	1

Table A.15: This table lists all 61 banks initially included in the 2011 EBA capital exercise. As this study wants to track the behaviour of independent banks over time, we exclude all banks which were acquired during the sample period, all banks which received capital injections during the pre-treatment period and all banks with negative levels of equity. This sample construction procedure finally leaves us with a sample of 46 EBA banks.The cross in the sample panel indicates the bank present in the sample.

Bank	Country	Sample
Erste Group Bank AG	Austria	X
Raiffeisen Bank International AG	Austria	X
KBC Bank NV	Belgium	
Bank of Cyprus Public Company Limited	Cyprus	
Cyprus Popular Bank Public Co. Ltd.	Cyprus	X
Danske Bank A/S	Denmark	
Jyske Bank A/S	Denmark	X
Nykredit Realkredit A/S	Denmark	X
Sydbank A/S	Denmark	X
OP Financial Group	Finland	X
BNP Paribas SA	France	X
Credit Agricole Group	France	X
Groupe BPCE	France	
Societe Generale	France	
Bayerische Landesbank	Germany	
Commerzbank AG	Germany	X
DekaBank Deutsche Girozentrale	Germany	
Deutsche Bank AG	Germany	X
Deutsche Zentral-Genossenschaftsbank AG	Germany	X
HSH Nordbank AG	Germany	
Hypo Real Estate Holding AG	Germany	
Landesbank Baden-W¨urttemberg	Germany	X
Landesbank Berlin Holding AG	Germany	
Landesbank Hessen-Th¨uringen Girozentrale	Germany	X
NORD/LB Norddeutsche Landesbank Girozentrale	Germany	X
Westdeutsche Genossenschafts-Zentralbank AG	Germany	X
Allied Irish Banks, Plc	Ireland	
Bank of Ireland	Ireland	X
Banca Monte dei Paschi di Siena SpA	Italy	X
Banco Popolare Societ Cooperativa	Italy	X
Intesa Sanpaolo SpA	Italy	X
UniCredit SpA	Italy	X
Unione di Banche Italiane SCpA	Italy	X
OTP Bank Nyrt.	Hungary	
Banque et Caisse d'Epargne de l'Etat	Luxembourg	
Bank of Valletta Plc	Malta	X
ABN AMRO Group NV	Netherlands	
ING Bank NV	Netherlands	X
Rabobank Group	Netherlands	
SNS Bank NV	Netherlands	X
DNB Bank ASA	Norway	X
Powszechna Kasa Oszczednosci Bank Polski SA	Poland	X
Banco BPI SA	Portugal	X

Table A.15 – *Continued from previous page*

Bank	Country	Sample
Banco Comercial Portugus SA	Portugal	X
Caixa Geral de Depsitos SA	Portugal	X
Espirito Santo Financial Group SA	Portugal	X
Nova Kreditna banka Maribor d.d.	Slovenia	X
Nova Ljubljanska Banka d.d.	Slovenia	X
Banco Bilbao Vizcaya Argentaria, SA	Spain	X
Banco Popular Espanol SA	Spain	X
Banco Santander SA	Spain	X
La Caixa	Spain	X
Nordea Bank AB	Sweden	X
Skandinaviska Enskilda Banken AB	Sweden	X
Svenska Handelsbanken AB	Sweden	X
Swedbank AB	Sweden	X
Barclays Plc	United Kingdom	X
HSBC Holdings Plc	United Kingdom	X
Lloyds Banking Group Plc	United Kingdom	X
Royal Bank of Scotland Group Plc	United Kingdom	X

Appendix B

Chapter 3

Figure B.1: Density of cost efficiency under SFA.The efficiency scores are calculated using SFA.The sample consists of 2630 banks.The sample period is 2010-2018.

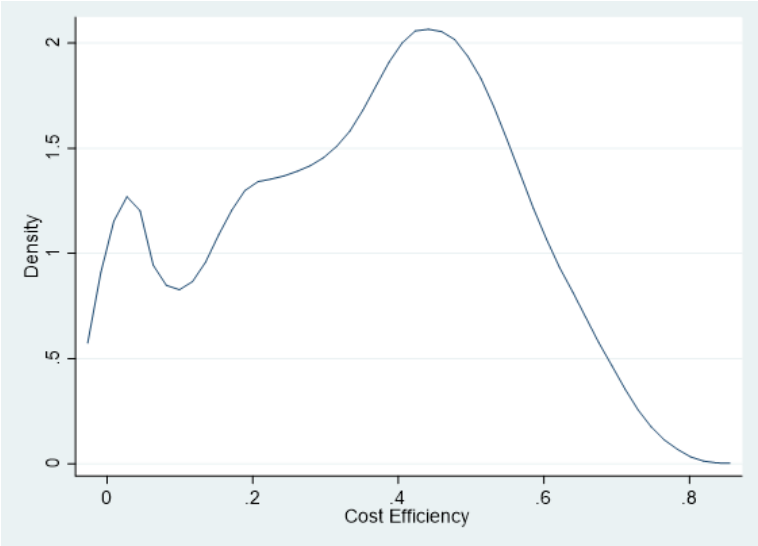


Table B.1: Descriptive statistics of Cost Efficiency Scores obtained using DEA.The sample consists of 2630 banks.The sample period is 2010-2018.The sample has 6 regions :- Africa,Asia-Pacific,Europe,Latin America and Caribbean,Middle East, and United States and Canada.

Region	Mean	Std. Dev.	Min	Max
Africa	0.576	0.071	0.428	1.000
Asia-Pacific	0.530	0.062	0.366	0.897
Europe	0.575	0.074	0.364	1.000
Latin America and Caribbean	0.546	0.069	0.393	1.000
Middle East	0.524	0.047	0.431	0.755
United States and Canada	0.563	0.067	0.388	0.765
Total	0.560	0.072	0.364	1.000

Figure B.2: Average Cost Efficiency over the sample period. Cost Efficiency scores are obtained using DEA.The sample period is 2010-2018.The sample consists of 2630 banks.The sample has 6 regions :- Africa,Asia-Pacific,Europe,Latin America and Caribbean,Middle East, and United States and Canada.

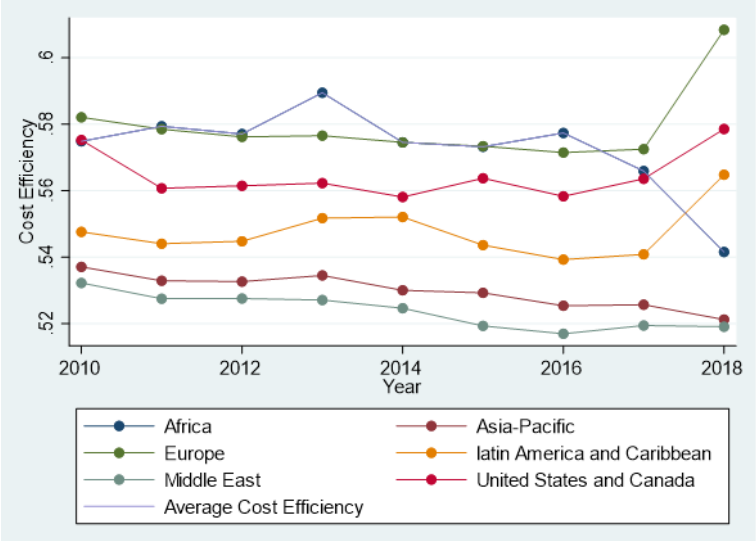


Table B.2: Descriptive Statistics of Cost Efficiency Scores obtained using DFA.The sample consists of 2630 banks.The sample period is 2010-2018.The sample has 6 regions :- Africa,Asia-Pacific,Europe,Latin America and Caribbean,Middle East, and United States and Canada.

Region	Mean	Std. Dev.	Min	Max
Africa	0.006	0.012	0.000	0.089
Asia-Pacific	0.014	0.026	0.000	0.272
Europe	0.024	0.046	0.000	0.690
Latin America and Caribbean	0.012	0.054	0.000	1.000
Middle East	0.021	0.058	0.000	0.556
United States and Canada	0.016	0.044	0.000	0.391
Total	0.020	0.046	0.000	1.000

Figure B.3: Density of Cost Efficiency under DEA.The efficiency scores are calculated using DEA.The sample consists of 2630 banks.The sample period is 2010-2018.

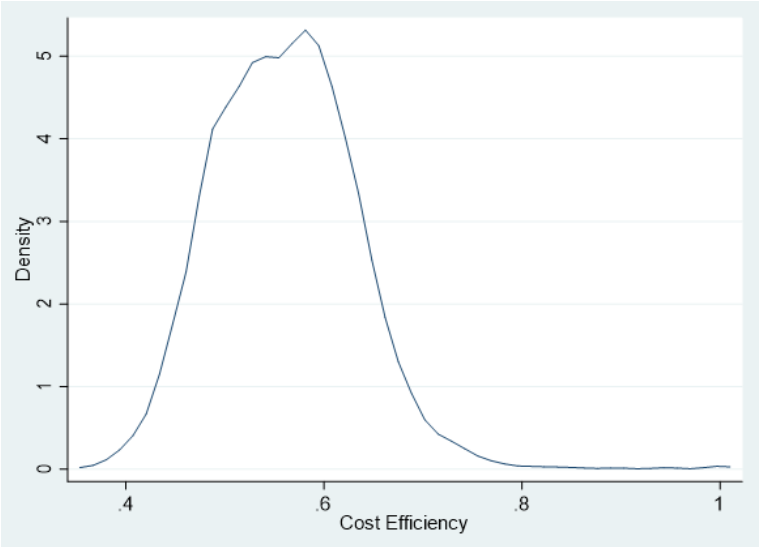


Figure B.4: Average Cost Efficiency over the sample period. Cost Efficiency scores are obtained using DFA.The sample consists of 2630 banks.The sample period is 2010-2018.The sample has 6 regions :- Africa,Asia-Pacific,Europe,Latin America and Caribbean,Middle East, and United States and Canada.

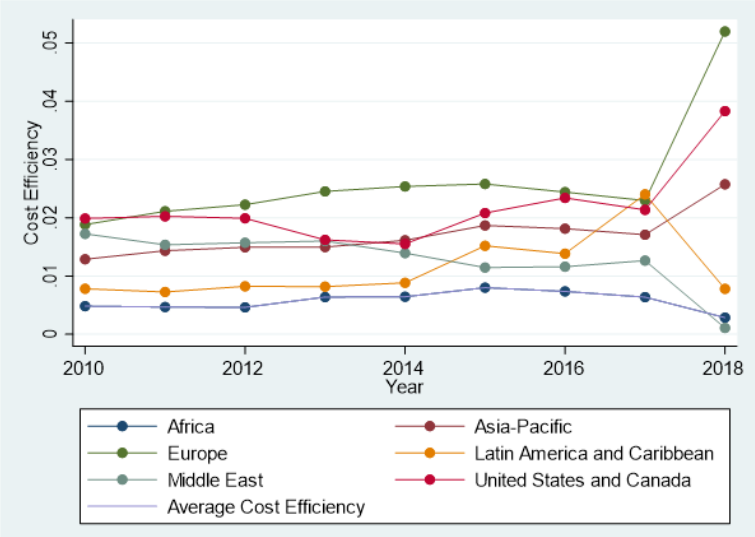


Figure B.5: Density of Cost Efficiency under DFA. Cost Efficiency scores are obtrained using DFA.The sample consists of 2630 banks.The sample period is 2010-2018.

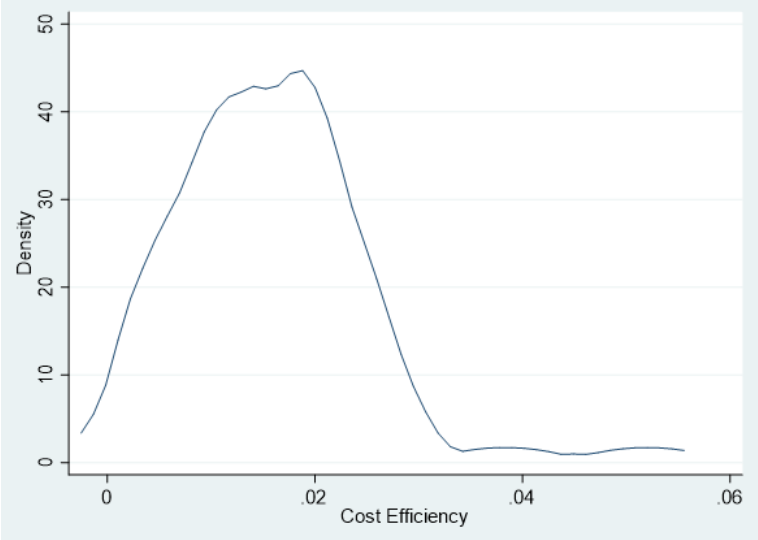


Table B.3: Descriptive statistics of Cost Efficiency Scores obtained using TFA.The sample consists of 2630 banks.The sample period is 2010-2018.The sample has 6 regions :- Africa,Asia-Pacific,Europe,Latin America and Caribbean,Middle East, and United States and Canada.

Region	Mean	Std. Dev.	Min	Max
Africa	0.011	0.017	0.000	0.187
Asia-Pacific	0.013	0.033	0.000	0.573
Europe	0.015	0.026	0.000	0.429
Latin America and Caribbean	0.012	0.015	0.000	0.315
Middle East	0.015	0.027	0.000	0.321
United States and Canada	0.014	0.023	0.001	0.292
Total	0.013	0.021	0.000	0.573

Figure B.6: Average Cost Efficiency over the sample period. Cost Efficiency scores are obtained using TFA.The sample consists of 2630 banks.The sample period is 2010-2018.The sample has 6 regions :- Africa,Asia-Pacific,Europe,Latin America and Caribbean,Middle East, and United States and Canada.

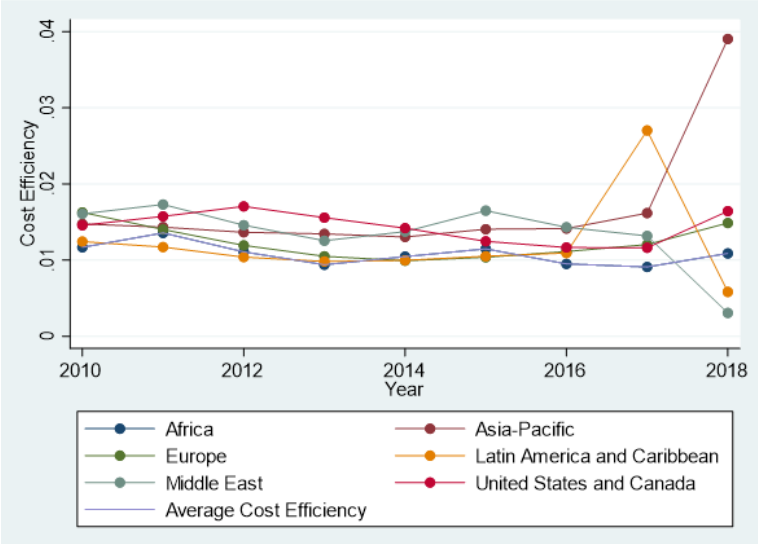
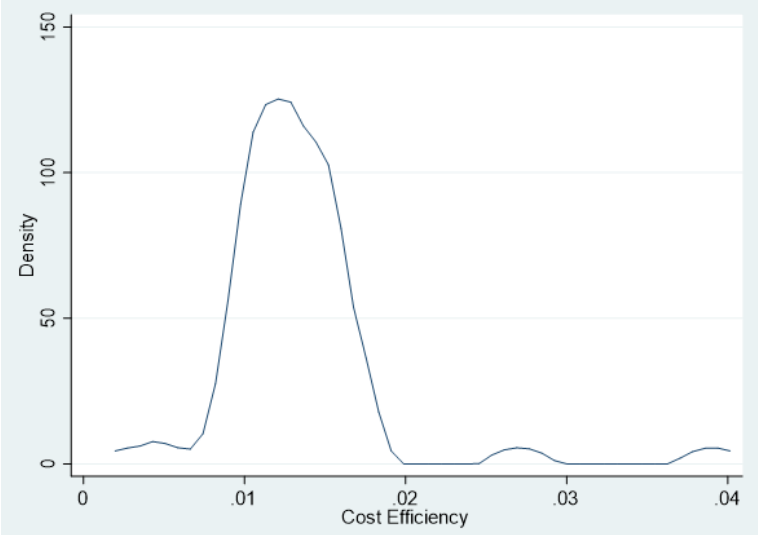


Figure B.7: Density of Cost Efficiency under TFA.The efficiency scores are calculated using TFA.The sample consists of 2630 banks.The sample period is 2010-2018.



Appendix C

Chapter 4

Figure C.1: Density of Technical Efficiency of the banks.The efficiency scores are obtained using WRDDM.The sample period is 2005-2019.The sample consists of 1931 banks.

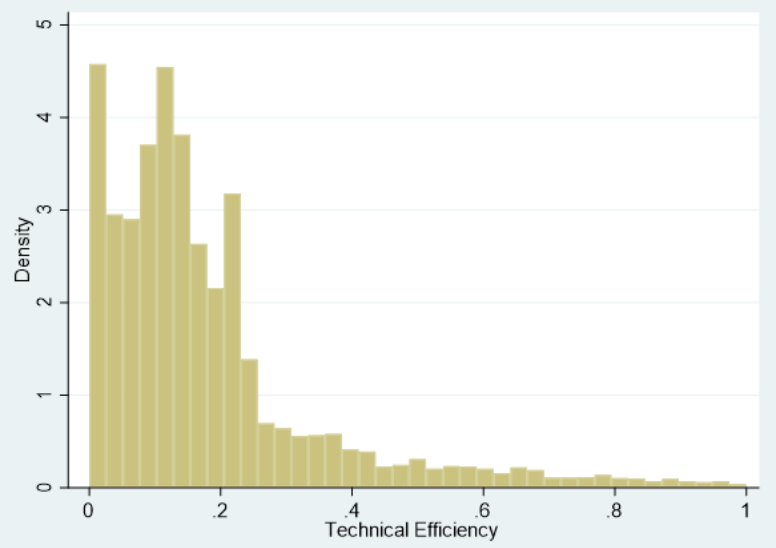


Table C.1: Correlation of Inputs and Outputs variables for WRDDM.WRDDM is used for calculating efficiency scores.The model is estimated using 3 inputs,2 outputs and 1 bad output.The inputs are the number of full-time employees, total deposits, and physical capital. The outputs are total loans and other earning assets.An undesirable output is Bad Loans.The sample period is 2005-2019.The sample consists of 1931 banks.(* statistically significant at 1% level)

	Labour	**Deposit**	**Physical Capital**	**Loans**	**Other Earning Assets**	**Bad Loans**
Labour	1					
Deposit	0.8609*	1				
Physical Capital	0.9200*	0.9007*	1			
Loans	0.8463*	0.9602*	0.9009*	1		
Other Earning Assets	0.7936*	0.9172*	0.8392*	0.9066*	1	
Bad Loans	0.7041*	0.7528*	0.7635*	0.8122*	0.7196*	1

Figure C.2: Technical Efficiency of the banks facing liquidity shock.The efficiency scores are obtained using WRDDM.The sample period is 2005-2019.A bank is defined as facing liquidity shock if the rate of change of the deposits of bank i is negative in t-1.

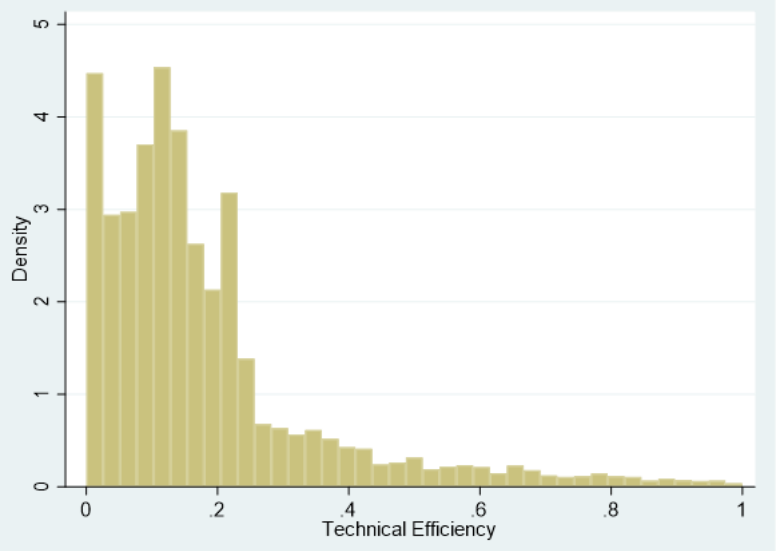


Figure C.3: Technical Efficiency of the banks not facing liquidity shock.The efficiency scores are obtained using WRDDM.The sample period is 2005-2019.A bank is defined as facing liquidity shock if the rate of change of the deposits of bank i is negative in t-1.

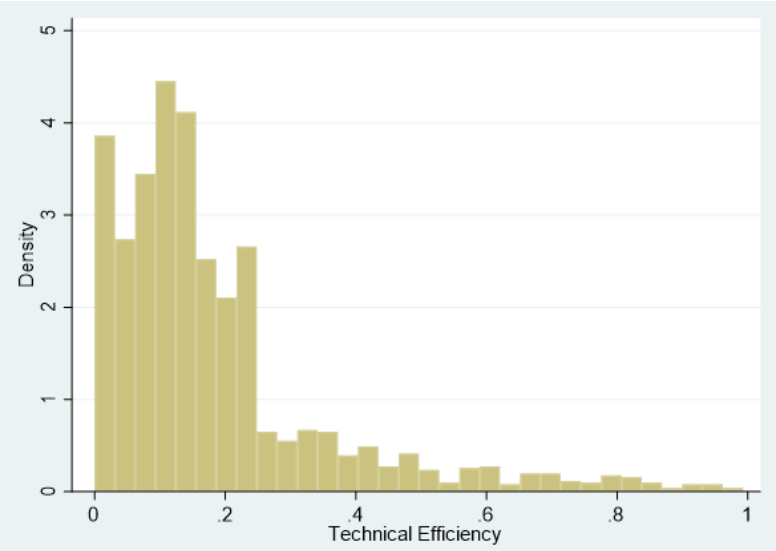


Figure C.4: Average Loan Exposure , Domestic Exposure , Foreign Exposure and Technical Efficiency of the banks facing liquidity shock across different countries over time.Technical Efficiency scores are obtained using WRDDM.Loan Exposure is the average of the Loans to Assets of the banks in the individual country.Foreign Exposure is the average of Foreign Exposure in Loans or Assets of the banks in the individual country.Domestic Exposure is the average of Domestic Exposure in Loans or assets of the banks in the individual country.Technical Efficiency is the average technical efficiency of the banks in the individual country.A bank is defined as facing liquidity shock if the rate of change of the deposits of bank i is negative in t-1.The sample period is 2005-2019.

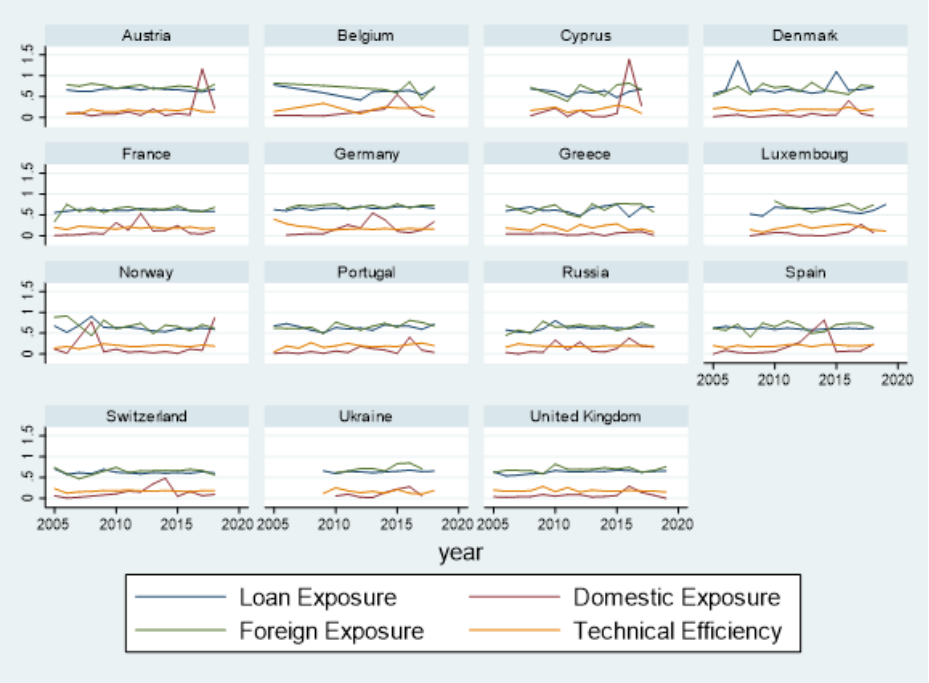


Figure C.5: Average Loan Exposure , Domestic Exposure , Foreign Exposure and Technical Efficiency of the banks not facing liquidity shock across different countries over time.Technical Efficiency scores are obtained using WRDDM.Loan Exposure is the average of the Loans to Assets of the banks in the individual country.Foreign Exposure is the average of Foreign Exposure in Loans or Assets of the banks in the individual country.Domestic Exposure is the average of Domestic Exposure in Loans or assets of the banks in the individual country.Technical Efficiency is the average technical efficiency of the banks in the individual country.A bank is defined as facing liquidity shock if the rate of change of the deposits of bank i is negative in t-1.The sample period is 2005-2019.

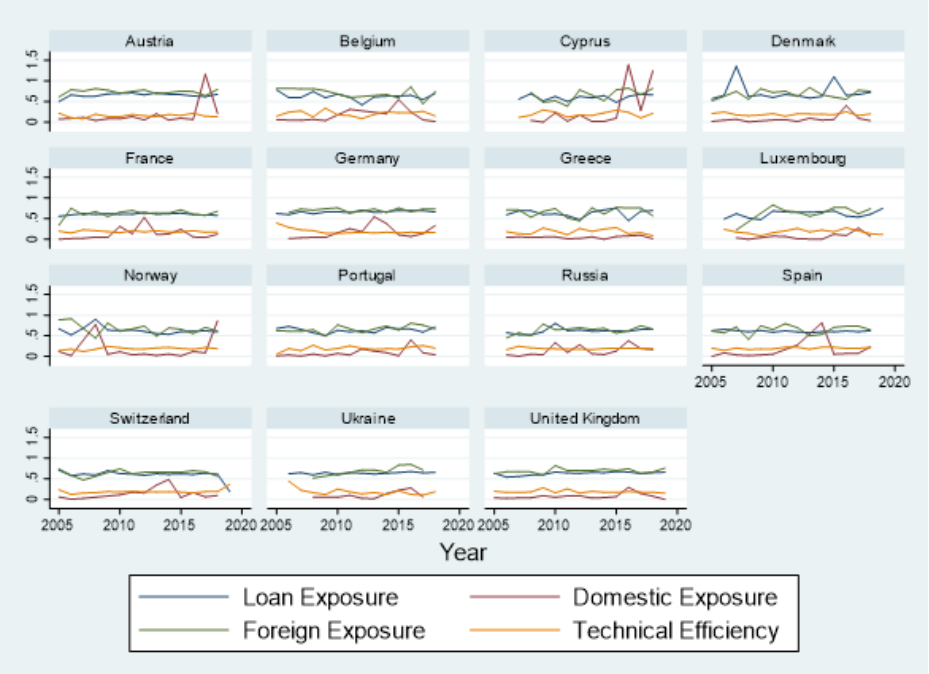


Table C.2: Descriptive Statistics for Inputs and Outputs variables For WRDDM.WRDDM is used for calculating efficiency scores.The model is estimated using 3 inputs,2 outputs and 1 badoutput.The inputs are the number of full-time employees, total deposits, and physical capital.The outputs are total loans and other earning assets.An undesirable output is Bad Loans.The sample period is 2005-2019.The sample consists of 1931 banks.

Year		Deposit	Labour	Fixed Assets	Loans	Other Earning Assets	Bad Loans
2005	Mean	35900	0.006	0.382	41600	72300	0.833
	Max.	230000	30.600	2113.233	236000	369000	5188
	Min.	0.026	0.016	0.000	0.017	0.036	0.192
	S.D.	67200	0.010	0.648	74100	127000	1600.756
2006	Mean	5657.266	0.002	0.116	7656.749	11900	0.907
	Max.	32500	19.156	736	51500	73900	7853
	Min.	32.755	0.017	2.544	0.659	85.609	0.000
	S.D.	10700	0.005	0.223	14500	21700	2136.821
2007	Mean	18200	0.002	0.179	15500	35600	0.624
	Max.	183000	15.163	1258.451	88700	228000	3533.862
	Min.	0.021	0.005	0.000	0.024	31.039	0.000
	S.D.	46900	0.004	0.367	26000	66300	0.968
2008	Mean	9238.196	0.005	0.159	12700	18800	1498.895
	Max.	111000	58.182	1667	139000	203000	12800
	Min.	0.000	0.006	0.000	0.000	0.207	0.000
	S.D.	28200	0.015	0.425	35700	51800	3731.752
2009	Mean	35600	0.013	0.662	47800	77600	3643.437
	Max.	403000	137.968	8020.612	433000	744000	25300
	Min.	0.230	0.025	0.001	0.022	0.320	0.000
	S.D.	103000	0.035	2043.178	112000	193000	7557.926
2010	Mean	17000	0.004	217.285	20000	38400	1389.856
	Max.	72200	17.958	960.208	84900	272000	16400
	Min.	0.051	0.017	0.001	0.021	0.061	0.058
	S.D.	24200	0.005	0.300	29600	71300	4180.414
2011	Mean	15200	0.004	0.391	26200	39900	2081.056
	Max.	142000	28.651	3724.328	186000	282000	19500
	Min.	0.004	0.012	0.000	0.019	0.068	0.000
	S.D.	36900	0.008	987.903	52300	80600	5172.587
2012	Mean	7260.734	0.003	0.150	7883.195	11400	1555.355
	Max.	40300	17.174	1086	48200	54400	17400
	Min.	0.093	0.069	0.001	0.056	0.117	0.000
	S.D.	11800	0.005	0.302	13000	15900	4438.370
2013	Mean	7248.936	0.002	0.084	6919.133	10900	0.292

Table C.2 – *Continued from previous page*

Year		Deposit	Labour	Fixed Assets	Loans	Other Earning Assets	Bad Loans
	Max.	24800	9.457	458.477	24100	35900	1047.133
	Min.	0.025	0.019	0.651	0.018	0.030	0.000
	S.D.	8921.144	0.003	0.133	8932.198	13600	0.347
2014	Mean	14700	0.005	0.248	19100	34200	1239.341
	Max.	117000	40.403	1965	170000	354000	9631
	Min.	0.050	0.021	0.000	0.003	200.988	0.000
	S.D.	29900	0.010	0.514	43500	89800	2767.746
2015	Mean	5906.645	0.003	0.102	6899.312	10300	0.274
	Max.	53800	20.106	1037.916	58800	92100	1347.079
	Min.	0.071	0.028	0.000	0.076	0.114	0.000
	S.D.	13600	0.005	0.261	14900	23400	0.378
2016	Mean	23700	20.507	0.565	23200	32500	1618.659
	Max.	263000	293.752	7469.784	267000	348000	21000
	Min.	3.851	0.011	0	0.008	0.023	0.000
	S.D.	67100	0.076	1914.842	68100	88700	5386.812
2017	Mean	16100	0.002	0.120	18400	72900	0.449
	Max.	107000	9.849	776.026	113000	721000	3845
	Min.	0.073	0.019	0.002	0.040	0.086	0.001
	S.D.	32700	0.003	0.208	36500	192000	0.996
2018	Mean	37200	0.012	0.425	56800	91100	5210.494
	Max.	458000	107.144	4616.816	738000	1160000	66200
	Min.	0.057	0.014	0.000	0.028	0.066	0.000
	S.D.	117000	0.031	1202.193	189000	299000	17000
2019	Mean	14700	0.004	0.168	16700	36900	0.733
	Max.	1250000	330.677	10800	1140000	3420000	75400
	Min.	0.000	0.000	0.000	0.000	0.000	0.000
	S.D.	67700	0.019	0.738	73100	196000	3642.060
	Mean	14700	0.004	0.170	16800	36900	0.745
	Max.	1250000	330.677	10800	1140000	3420000	75400
Total	Min.	0.000	0.000	0.000	0.000	0.000	0.000
	S.D.	67500	0.019	0.740	73100	195000	3681.784

Figure C.6: Density of Technical Efficiency of the banks using DEA. DEA is used for calculating efficiency scores.The sample period is 2005-2019.The sample consists of 1931 banks.

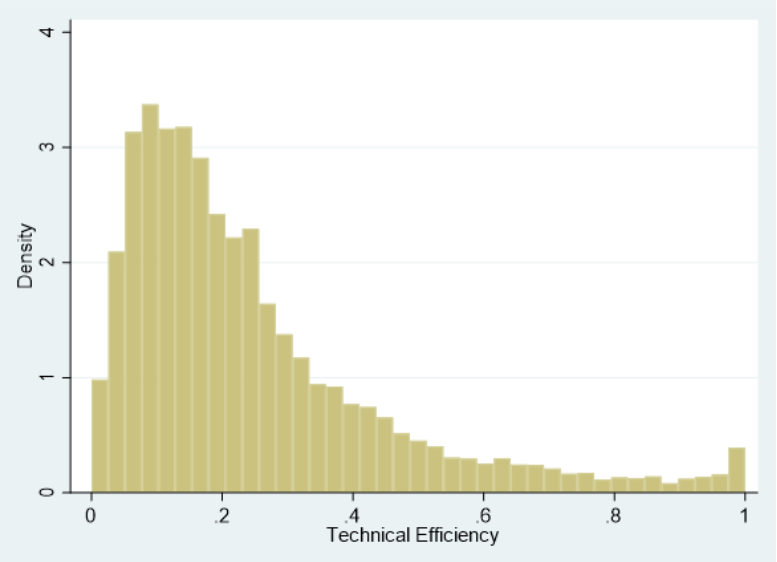


Figure C.7: Technical Efficiency of the banks using DEA facing liquidity shock. DEA is used for calculating efficiency scores.The sample period is 2005-2019.A bank is defined as facing liquidity shock if the rate of change of the deposits of bank i is negative in t-1.

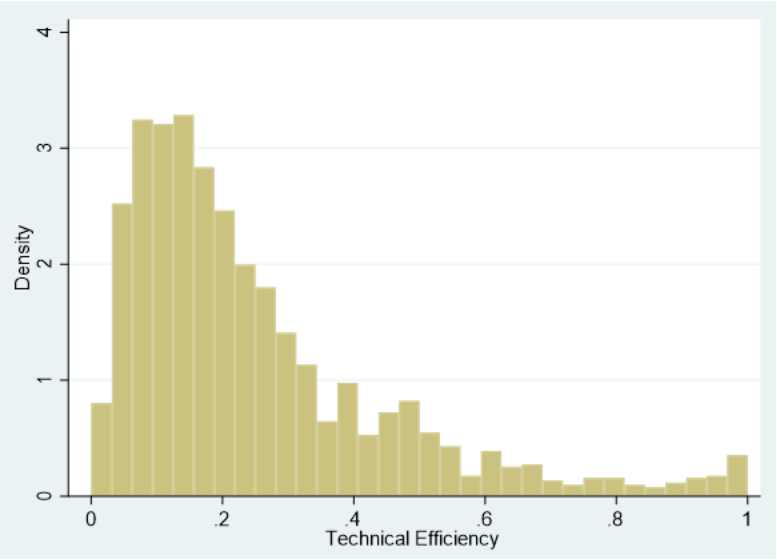


Figure C.8: Technical Efficiency of the banks using DEA not facing liquidity shock . DEA is used for calculating efficiency scores.The sample period is 2005-2019.A bank is defined as facing liquidity shock if the rate of change of the deposits of bank i is negative in t-1.

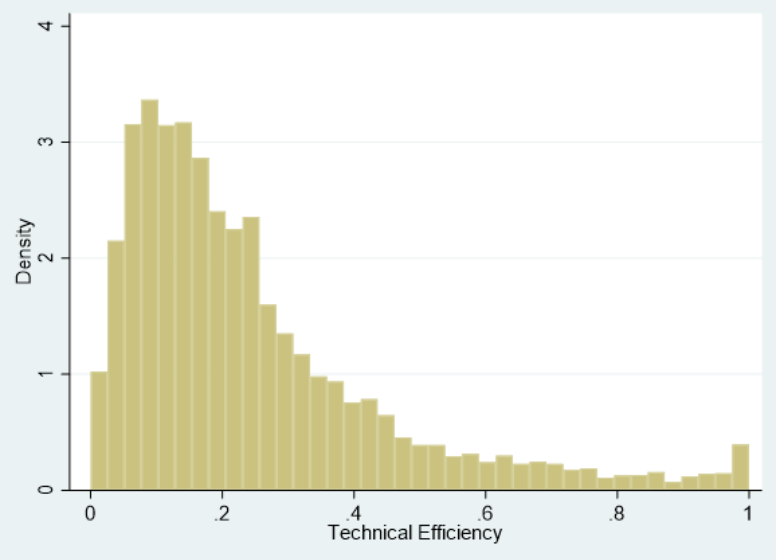


Figure C.9: Average Technical Efficiency of the banks across different countries over time using DEA.Technical Efficiency scores are obtained using DEA.Average Technical Efficiency is the average technical efficiency of the banks in the individual country.Average Technical Efficiency of the countries is the average technical efficiency of the 15 countries in the sample.The sample period is 2005-2019.The sample consists of 1931 banks.

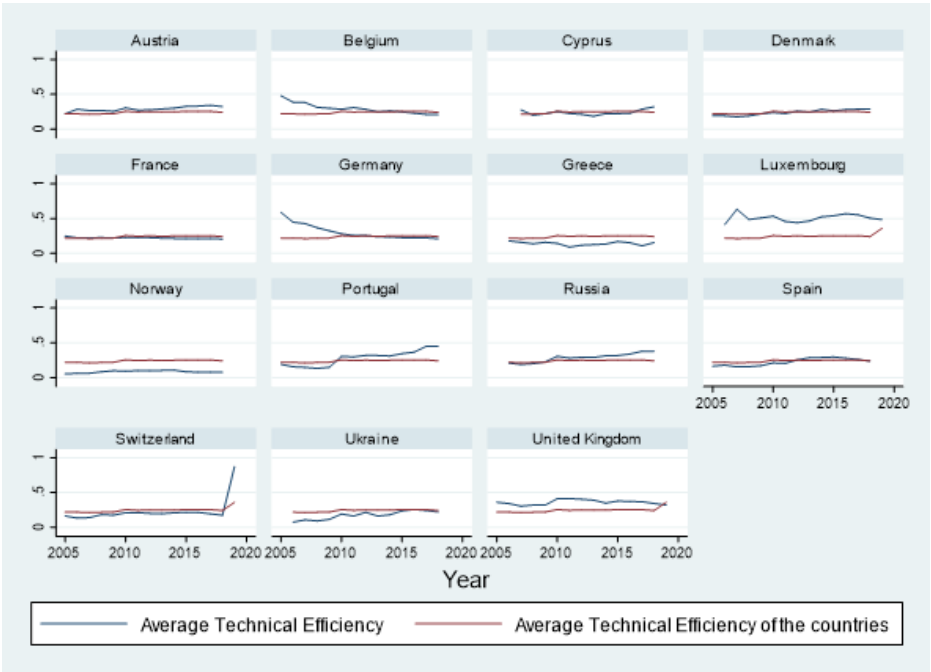


Figure C.10: Average Technical Efficiency of the banks across different countries over time using DEA.Technical Efficiency scores are obtained using DEA.Average Technical Efficiency is the average technical efficiency of the banks in the individual country. Average Technical Efficiency of banks facing liquidity shock is the average technical efficiency of the banks facing liquidity shock in the individual country. Average Technical Efficiency of banks not facing liquidity shock is the average technical efficiency of the banks facing not liquidity shock in the individual country.A bank is defined as facing liquidity shock if the rate of change of the deposits of bank i is negative in t-1.The sample period is 2005-2019.The sample consists of 1931 banks.

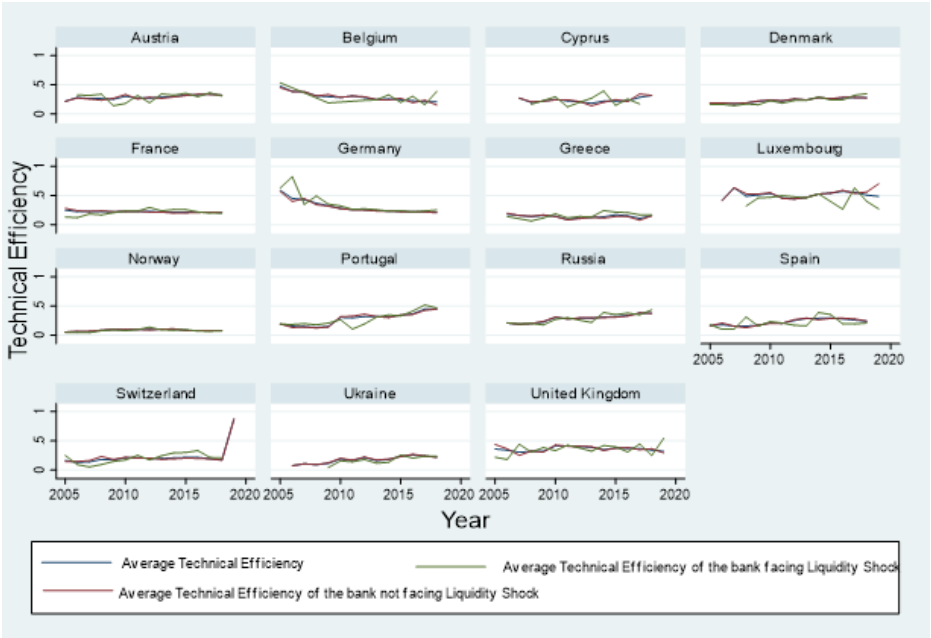


Figure C.11: Average Loan Exposure , Domestic Exposure , Foreign Exposure and Technical Efficiency of the banks across different countries over time using DEA.Technical Efficiency scores is obtained using DEA.Loan Exposure is the average of the Loans to Assets of the banks in the individual country.Foreign Exposure is the average of Foreign Exposure in Loans or Assets of the banks in the individual country.Domestic Exposure is the average of Domestic Exposure in Loans or assets of the banks in the individual country.Technical Efficiency is the average technical efficiency of the banks in the individual country.A bank is defined as facing liquidity shock if the rate of change of the deposits of bank i is negative in t-1.

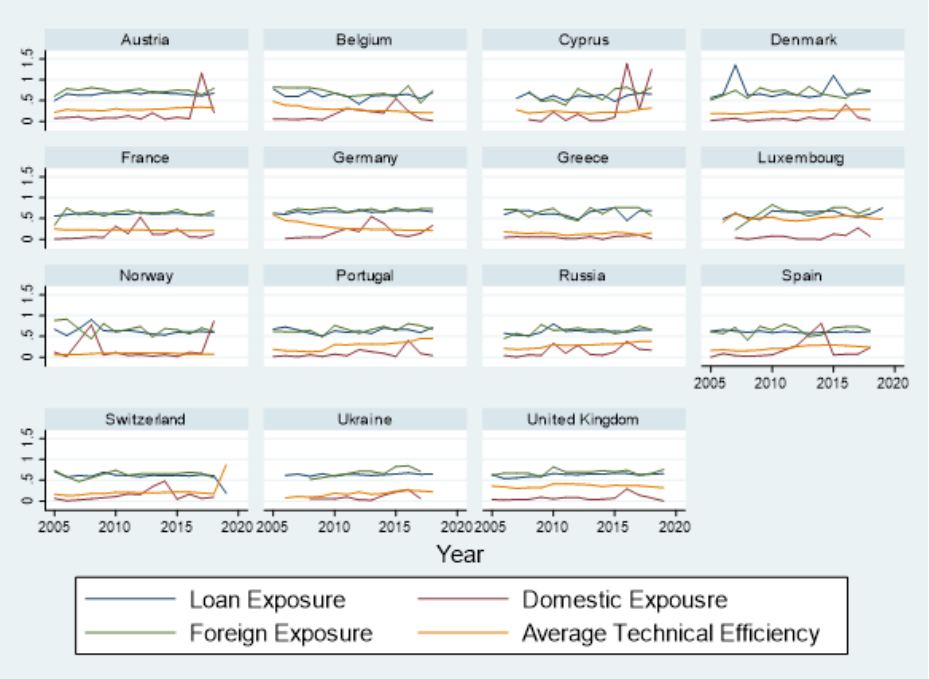


Table C.3: Fixed Effect Panel model results for the banks in countries with higher Financial Development than the average Financial Development of the sample for the period 2005-2019. The dependent variable is Technical Efficiency scores calculated using Weighted Russell Directional Distance Model. Model 1 controls for bank characteristics. Model 2 controls for bank characteristics and Macroeconomic Conditions. Model 3 controls for bank characteristics ,Macroeconomic Conditions and Domestic and Foreign Exposures. Model 4 controls for bank characteristics, Macroeconomic Conditions and Exposures in different regions. Reported are the standard errors in the brackets..The control variables have been standardised.(***Statistically significant at 1% level, **Statistically significant at 5% level, *Statistically significant at 10% level).

VARIABLES	Model 1	Model 2	Model 3	Model 4
LOGTA	0.003*	0.003*	0.004*	0.005***
	(0.002)	(0.002)	(0.002)	(0.002)
NPL	-0.005**	-0.005**	-0.005*	-0.005**
	(0.002)	(0.002)	(0.003)	(0.003)
LOANTA	-0.008***	-0.008***	-0.008***	-0.008***
	(0.002)	(0.002)	(0.002)	(0.002)
EQASS	0.002**	0.002*	0.002	0.002**
	(0.002)	(0.002)	(0.002)	(0.002)
ROE	0.001	0.001	-0.000	0.000
	(0.002)	(0.002)	(0.002)	(0.002)
GDPGR		0.002**	0.000**	0.001
		(0.004)	(0.004)	(0.004)
DEXP			0.007***	0.002**
			(0.002)	(0.004)
FEXP			0.001**	
			(0.002)	
EUROEXP				0.063**
				(0.029)
NAMEXP				0.081*
				(0.049)
SAMEXP				-0.043**
				(0.075)
AFEXP				-0.013*
				(0.009)
ASEXP				-0.006**
				(0.064)
LIQShOCK	0.002***	0.001***	0.001***	0.001***
	(0.005)	(0.005)	(0.005)	(0.005)
Constant	0.184***	0.182***	0.185***	0.183***
	(0.002)	(0.004)	(0.005)	(0.004)
Time Fixed Effect	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes
R-squared	0.432	0.421	0.594	0.632
Hausman Test	42.85	43.25	48.67	50.61
Observations	18,435	18,435	18,400	18,240

Table C.4: Fixed Effect Panel model results for the banks in countries with lower Financial Development than the average Financial Development of the sample for the period 2005-2019. The dependent variable is Technical Efficiency scores calculated using Weighted Russell Directional Distance Model.Model 1 controls for bank characteristics. Model 2 controls for bank characteristics and Macroeconomic Conditions. Model 3 controls for bank characteristics ,Macroeconomic Conditions and Domestic and Foreign Exposures. Model 4 controls for bank characteristics, Macroeconomic Conditions and Exposures in different regions. Reported are the standard errors in the brackets. The control variables have been standardised. (***Statistically significant at 1% level, **Statistically significant at 5% level, *Statistically significant at 10% level).

VARIABLES	Model 1	Model 2	Model 3	Model 4
LOGTA	0.003**	0.003*	0.005**	0.006**
	(0.002)	(0.002)	(0.002)	(0.002)
NPL	-0.005***	-0.005***	-0.006***	-0.006***
	(0.002)	(0.002)	(0.002)	(0.002)
LOANTA	-0.024***	-0.024***	-0.025***	-0.026***
	(0.004)	(0.004)	(0.004)	(0.004)
EQASS	-0.002**	-0.002	-0.001**	-0.001**
	(0.003)	(0.003)	(0.003)	(0.003)
ROE	0.000	-0.000**	-0.001	-0.001
	(0.002)	(0.002)	(0.002)	(0.002)
GDPGR		0.004*	0.006	0.007**
		(0.003)	(0.003)	(0.003)
DEXP			0.009	0.011**
			(0.002)	(0.005)
FEXP			0.834***	
			(2.068)	
EUROEXP				0.021
				(0.034)
NAMEXP				0.017
				(0.042)
SAMEXP				0.025**
				(0.052)
AFEXP				0.007***
				(0.006)
ASEXP				0.036**
				(0.046)
LIQShOCK	0.011**	0.012**	0.012**	0.011**
	(0.005)	(0.005)	(0.006)	(0.006)
Constant	0.180***	0.174***	0.213**	0.171***
	(0.003)	(0.005)	(0.104)	(0.005)
Time Fixed Effect	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes
R-squared	0.534	0.573	0.591	0.639
Hausman Test	37.26	41.65	47.28	53.50
Observations	10,530	10,530	10,500	10,460

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