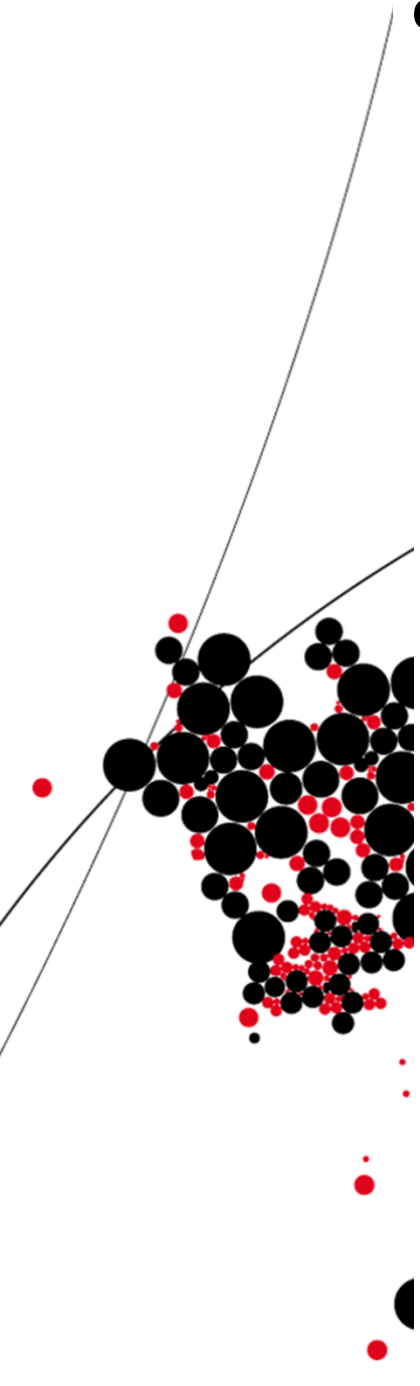
UNIVERSITY OF TWENTE.

Faculty of Behavioural, Management and Social sciences

The relation among non-performing loans, operating efficiency, and capitalization in commercial banking



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Preface

This thesis is the final part of the curriculum for the master Business Administration at the University of Twente. I started the phase on the first of February 2017 at the department Financial Services Organisation (FSO) at Ernst and Young Amsterdam.

First, I want to thank EY FSO Amsterdam, and by person my supervisor Jules Gerritsen for the guidance and welcome working atmosphere during the last phase. During this time, I wrote my thesis and assisted EY during the so called “busy season”. I experienced the time as an inspiring learning process, for as well auditing as writing the thesis. I had a sharp mentor who proven to be an excellent sparring partner. Secondly, I want to thank dr. S.A.G. Essa and prof. dr. R. Kabir, for the feedback sessions and I really appreciate the time they made for me during the completion of this study. Their academic knowledge and classes about the financial sector gave me the courage to explore for me, the unfamiliar banking sector.

Finally, I want to thank my family and friends who were there for me during the process.

I hope you enjoy reading

Chiel van Benthem

Amsterdam, July 27, 2017

Abstract

This study examines the relationship among non-performing loans, operating efficiency, and capitalization. The study tests five hypotheses, namely "bad management", "skimping", 'bad luck", "moral hazard", and "regulation". The dataset contains thirty of the largest worldwide commercial banks, measured in total assets. In addition, the study tries to test for differences in European commercial banks. The findings are multisided; the analysis shows evidence for "bad management" which is considered leading for the entire dataset. The result indicates that increases in operating efficiency are followed by higher levels of non-performing loans, which suggest management behaviour influences non-performing loans. Secondly, the "skimping" hypothesis is confirmed for a sub-sample of the most efficient banks suggesting management of the banks deliberately save on short-term non-interest expenses e.g. monitoring costs which lead to higher ratios of non-performing loans in the future. Thirdly, "bad luck" is supported for European banks, suggesting external events affect non-performing loans. Fourthly, "moral hazard" in the banking sector is confirmed for the separate samples of most efficient as well for the most inefficient banks. In short, capitalization decreases are followed by increases in non-performing loans, indicating banks' management have incentives to increase the risk in their portfolios. Finally, the "regulation" hypothesis is supported for the European sample, implying increases in non-performing loans lead to greater capital ratios. The finding suggests that the Basel III regulation is having the desired effect as regulators implied. In closing, the practical implications, limitations and future research recommendations are discussed in section 5.

Keywords*: non-performing loans, operating efficiency, capitalization, management behaviour, external events, Granger-causality.*

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1. INTRODUCTION

Financial markets have an important role in the global economy (Alfaro, Chanda, Kalemli-Ozcan, & Sayek, 2004). In 2008, once again a financial crisis has led to financial instability of banks. As a consequence, reductions in leverage and the use of long-term debt for companies worldwide are observed, which restrains economic growth. Furthermore, "market failures and policy distortions" shift the use of long term finance to short term, which transfers more risk to the users of debt[1]. Besides, finance is about transferring assets from entities who own it to entities who need it. Banks have the function to lift growth in several ways; firstly, by rewarding savers to the risk they are exposed to, which supports savers and investments, and secondly, if the funds are allocated in an efficient way, finance should trigger more growth (Beck, Georgiadis, & Straub, 2014; Greenwood, Sanchez, & Wang, 2013; Haldane, Brennan, & Madouros, 2010; King & Levine, 1993; Oks, 2001; Philippon & Reshef, 2013). Hence, the recent financial crisis sparked questioning the financial stability of the banking sector (Haldane et al., 2010; Philippon & Reshef, 2013).

In the last decades, previous studies showed that management quality and external events linked to efficiency, non-performing loans (henceforth, NPLs) and capitalization are variables that affect banks to a large magnitude (Berger & DeYoung, 1997; Fiordelisi, Marques-Ibanez, & Molyneux, 2011; Podpiera & Weill, 2008; Reddy, 2011; Rossi, Schwaiger, & Winkler, 2005; Tabak, Craveiro, & Cajueiro, 2011; Williams, 2004). In particular, understanding the factors accountable to financial instability are of interest (Khemraj & Pasha, 2009). One of the explanations of financial instability during the crisis is due to bad loans i.e. NPLs (Messai & Jouini, 2013). More specifically, many studies found that almost all banks who are failing have big amounts of NPLs and is a sign of insolvency (Barr, Seiford, & Siems, 1994; Demirguc-Kunt, 1989; Ghosh, 2015; Lu & Whidbee, 2013; Whalen, 1991). A second, explanation is the large cost differences between banks. Several studies find mostly found that a bank suffers high costs and generates low profits. These differences are X-inefficiencies, which are organisations working in their production possibilities frontier such as agency conflicts, management problems or other inefficiencies (Berger & Humphrey, 1991; Berger, Hunter, & Timme, 1993; DeYoung, 1998; Staub, Souza, & Tabak, 2010). Some of these studies reveal that the X-inefficiencies are estimated between the 20 and 25% of all costs at an average bank (Bauer, Berger, & Humphrey, 1993; DeYoung, 1998; Kwan, 2006).

[1] Information retrieved from World bank June 14, 2016

The factors described above are related; first because banks who have high ratios of NPL have low cost efficiency (Altunbas, Carbo, Gardener, & Molyneux, 2007; Barr et al., 1994; Demirguc-Kunt, 1989; Fan & Shaffer, 2004; Girardone, Molyneux, & Gardener, 2004; Karim, Chan, & Hassan, 2010; Whalen, 1991). Additionally, Peristiani (1997) and DeYoung (1998) found that there is a relationship between asset quality and management quality. Secondly, NPL ratios and capital adequacy ratios – i.e., equity to total assets ratio – are seen as the most common risks for efficiency of banks when studying literature about variables. Because, inefficient banks continually seem to have low ratios of capital and high ratios of NPLs (Altunbas, Liu, Molyneux, & Seth, 2000; Berger et al., 1993; C. Chang, 1999; T. C. Chang & Chiu, 2006; Chiu & Chen, 2009; Chiu, Chen, & Bai, 2011; Chiu, Jan, Shen, & Wang, 2008; Drake & Hall, 2003; Girardone et al., 2004; Hughes, 1999; Hughes, Mester, & Moon, 2001; Mester, 1996; Pastor, 1999). Efficiency can be seen as the cost function, that assumes that a bank exaggerates earnings, or the other way around, reduces costs for all levels of output (Berger & Humphrey, 1991; Berger et al., 1993; Daley & Matthews, 2009; DeYoung, 1998).

In congruence with the explanations describe above, Berger and DeYoung (1997) investigate four management related hypotheses in relation with efficiency, NPLs and capitalization in the United States. Namely; "bad management", "bad luck", "skimping", and "moral hazard". Indeed, they found significant evidence for an intertemporal relationship between NPLs and efficiency; firstly, they tested "bad management" which is in favour for the whole dataset. In other words, decreasing efficiency is due to the lack of skills of the management which causes increases in NPLs. Secondly, they found an adverse relation – i.e., "bad luck" – which states NPLs are increasing because of external events – e.g., increasing unemployment rates – and therefore efficiency declines. On the contrary, this paper investigates the relation between NPL and capitalization namely "moral hazard" as it is a typical problem of taking unnecessary risk when other parties are bearing the risk – e.g., debtors – and it could be an alternate clarification of high levels of bad loans (Berger & DeYoung, 1997). Hence, management of thinly capitalized banks have incentives to attract more risky loans and thereby NPLs increase. More recent, several more studies were conducted with the suggested approach with similar findings such as, Williams (2004), Rossi et al. (2005), Podpiera and Weill (2008), Fiordelisi et al. (2011), Tabak et al. (2011), Reddy (2011), and Louzis, Vouldis, and Metaxas (2012). In addition, this study adds a new aspect, namely the "regulation" hypothesis. The hypothesis is testing the effectiveness of the Basel III regulation – more risky loan portfolios should lead to higher levels of capital buffers. Jacques and Nigro (1997) found evidence for a

similar construct in the U.S., where risk based capital standards increased capitalization. In brief, because the financial crisis questioned the financial stability and literature implies there are intertemporal relations between – NPLs and efficiency and NPLs and capitalization – and we do not know if it is exogenous or endogenous this study investigates the above proposed constructs for commercial banks both worldwide as in the European Union (henceforth EU).

1.1 Problem statement

Following the literature, this paper has multisided aims; on the one hand the estimation of operating efficiency could be improved, although it alters on the relation between operating costs and NPLs. Therefore, the following research aims are developed to determine: firstly, in line with described above, the causes of bad loans and financial instability of commercial banks are researched during the financial crisis of 2008. Secondly, identifying the right focus for policy institutions e.g. Basel to encourage banks' not taking excessive risks in their asset portfolios. And thirdly, proposing a backed approach to accurately estimate the operating efficiency of banks. Hence, determining the above described depends on finding the relationships between NPLs, operating efficiency, and capitalization of commercial banks.

To execute the study, this paper will follow the initial proposed methodology of Berger and DeYoung (1997) which is followed by several other researchers e.g. Ghosh (2015) and Louzis et al. (2012). The hypotheses are partially adopted from Berger and DeYoung (1997), therewith, this study will research the intertemporal relationships among NPLs, operating efficiency, and capitalization by testing five hypotheses. First, the intertemporal relation between NPLs and operating efficiency is tested through "bad luck", "bad management" and "skimping". Second, the intertemporal relationship between NPL and capitalization will be investigated. Accordingly, the hypothesis described as "moral hazard" will be tested. While the 'moral hazard" hypothesis does not clarify the relation between operating efficiency and NPLs, this study adopts the hypothesis suggested by Berger and DeYoung (1997) as it could be an alternative explanation for increasing NPLs. In addition, this paper adds an extra hypothesis which intends to test the Basel III regulation. This study will adopt the "regulation" hypothesis from Altunbas et al. (2007) to test this relationship. The hypotheses formulated in this study show coexisting relations between operating efficiency and NPLs, but with inverse signs and therefore testing other constructs, therefore this study conducts a Granger-causality analyses which will be elaborated in section 3. Adding up all the research areas, the following research question will be answered:

"*What is the intertemporal relation among non-performing loans, operating efficiency, and capitalization and how does it affect commercial banks"*

Sub questions:

- *What is the effect of external events or "bad luck" to NPL on operating efficiency?*
- *What is the effect of indigenous risks e.g. poor senior management or "bad management" on the relation between operating efficiency and NPL?*
- *What is the effect of cutting in short term operating costs or "skimping" on the relation between efficiency and NPL?*
- *What is the effect of high risks on loans on behave of the shareholders of banks with low capital or "moral hazard" on the relation between NPL and capitalization?*
- *What is the effect of the Basel III regulation on the relation between NPL and capitalization?*

1.2 Academic and practical relevance

Previous research primarily focused on macroeconomic influences – i.e., external events – on NPLs for both worldwide and EU samples. First, the relevance of this paper from a scientific perspective is to provide empirical evidence for the EU and worldwide, since not much research has been done with an up-to-date dataset during the financial crisis of 2008. Second, the study can better help understand how operating efficiency, performance indicators i.e. ROA, NPLs and capitalization are related to each other. Third, the additional hypothesis adds a new angle and tests if the Basel III regulation is having its proposed effect in the banking sector.

In a practical view this paper could be relevant in better estimations of operating efficiency for commercial banks. Therefore, commercial banks have more understanding which factors influence operating efficiency. Finally, for regulators and policy makers the results can give a better understanding how to control bank instability and potential failures and monitor the current regulation and policies and possibly advert future financial instability.

The rest of the paper is organised in five sections. In the next section, the theoretical aspects of efficiency of commercial banks will be elaborated. Here, the background of the commercial banks, factors that influence efficiency, NPL, capitalization, control variables and previous findings will be described by findings in the literature. Thereafter, the research design, sample size and variables are described to execute the three equations for data analysis. As

follows, the hypotheses will be tested for Granger-causality and the results of the regression will be given. Finally, the conclusions, discussion and limitations of the research are presented and an outlook for further research and practical implications will be given.

2. LITERATURE REVIEW

In the following section, several basic concepts will be elaborated to understand the context of NPLs and the relationship to operating efficiency and capitalization. Thereby this paper tries to give a comprehensive literature overview from the EU regions as well as worldwide. Moreover, this section explains the constructs used in the research model, including the development of the five hypotheses and elaborates on previous findings on the issues described.

2.1 Banks and background

The financial sector has a worldwide influence on the economy, since more financial intermediation should generate further growth. However, there are factors which can negatively influence growth, in particular the financial crisis of 2008 is one of these causes (Haldane et al., 2010; Philippon & Reshef, 2013). Previous papers showed that the management quality and external events linked to efficiency, NPLs and capitalization are variables that affect banks to a large magnitude (Berger & DeYoung, 1997; Fiordelisi et al., 2011; Podpiera & Weill, 2008; Reddy, 2011; Rossi et al., 2005; Tabak et al., 2011; Williams, 2004).

Commercial banks are financial institutions who provide services for individuals, companies and institutes[2]. This study adopts the definition of the ECB (European Central Bank) for commercial banks, which are part of a group of Monetary Financial Institutions (MFIs), which means a credit institution or another financial institution *"whose business is to receive deposits and/or close substitutes for deposits from entities other than MFIs and, for its own account (at least in economic terms), to grant credits and/or make investments in securities"*[3]. Under the umbrella of MFIs we define commercial banks, investment banks, money market funds etc. Other definitions have been searched to determine comparison among scholars. However, the explanation of the term lacks in literature. Hence, the definition for banks of the ECB is adopted. The main focus of the paper is on commercial banks who provide services to clients – e.g., loans and mortgages. Whose function is to translocate resources from those entities who have it, to that need it. During the process of intermediation of funds the risk is reduced, liquidity is provided and information asymmetry is condensed (Haldane et al., 2010; Philippon & Reshef, 2013). The banking sector, and particular the financial crisis as a whole has led to a reduction in leverage and long-term debt. Since long-term debt can be a vital factor

[2] Information retrieved from Financial Times on June the 2th, 2017.
[3] Information retrieved from ECB/2008/32, paper 2.

for economic growth, the findings described above are considered as a potential problem for economic growth[4].

As described, the commercial banking sector has a great influence on financial markets and the economy, for this reason it is more important to know the relation among NPLs, operating efficiency, and capitalization since it could trigger financial depressions as we have seen in the past. The next section will predominantly be elucidative on the fundamental features of bank efficiency.

2.2 Bank efficiency

After an extensive literature review, operating efficiency can be defined as: *the cost function that assumes that banks exaggerate earnings, or the other way around, it's not about increasing income, but reducing costs for all levels of output (Berger & DeYoung, 1997; Berger & Humphrey, 1991; Daley & Matthews, 2009)*. To begin with, commercial banking is one of the most difficult to measure output (Basu & Wang, 2006; Berger & Humphrey, 1991; Colangelo & Inklaar, 2012; Triplett & Bosworth, 2004). Hence, choosing the important variables of banking that composes outputs is difficult because of the fact banks do not charge explicit fees for the services they provide (Basu & Wang, 2006; Berger & Humphrey, 1991; Colangelo & Inklaar, 2012). Despite of the challenge to measure operating efficiency, the next paragraph will elaborate which potential factors can influence bank efficiency.

2.2.1 Factors influencing bank efficiency

In the last decades, numerous research has been done in the field of banking. One of the areas that has been researched is about the matter of NPL. Almost all studies found that the causes of bank failure of institutions are in relation with big amounts of NPLs before failure and the measure for asset quality is a significant predictor of insolvency (Barr et al., 1994; Demirguc-Kunt, 1989; Shaffer, 2012; Whalen, 1991).

Secondly, the other study area that has been researched focused on the factors that have influence on efficiency and find large differences in efficiencies between comparable banks. One of these are X-inefficiencies, which are organisations working in their production possibilities margin because of – e.g., agency conflicts, management problems, operating cost inefficiencies and other inefficiencies (Berger & DeYoung, 1997; Berger & Humphrey, 1991;

[4] Information retrieved from World Bank.

Berger et al., 1993; DeYoung, 1998). X-inefficiencies are estimated between the 20 – 25% of costs at the average bank (Bauer et al., 1993; Berger & Humphrey, 1991; DeYoung, 1998; Kwan, 2006). For example, one of these X-inefficiencies are found by Berger and Humphrey (1991). Their results conclude that the dispersal in the costs of bank are mostly inefficiencies rather than market factors such as differences in input prices – i.e., you need money of people to lend it to others – scale of operations, or product diversity. Expect for the largest banks, the inefficiencies, which mainly consist of operating cost inefficiencies such as labour cost and capital inputs (e.g. buildings, deposit/savings account, cash held by banks), rather than financial, involving interest cost.

Thirdly, other literature available emphasises on the effects of size i.e. scale economies on operating efficiency. Kovner, Vickery, and Zhou (2015) examined a sample of 2,810 banks in the U.S. over a period from 2001 till 2012 and researched the relation between scale economies and operating efficiency of banks. Their results show that bank holding companies have indeed lower operating costs in the most parts of non-interest expense, and therefore have higher efficiency ratios than other banks. The biggest cost savings are measured in employee compensation, fixed assets, overhead, and IT and data processing. Furthermore, Cornett, McNutt, and Tehranian (2006) studied a sample of 134 mergers in the US between 1990 and 2000 and found similar evidence for efficiency enhancements after large mergers of banks. Additionally, Niepmann (2013) found comparable results for a sample of 1,998 banks in Germany, the study found evidence that bank size has a negative influence on operating costs.

In summary, this paper tries to give a comprehensive overview of the most important literature available in relation with the factors influencing bank efficiency. Based on the findings, NPLs are considered as a main catalyst for bank failure. Moreover, the high ratios of X-inefficiencies suggest these could also explain why banks fail. Size is clearly influencing efficiency, however there is no direct link to bank failure. Therefore, this paper will further examine NPLs and efficiency in the following sections.

2.2.2 Linking NPLs and bank efficiency

In the above described topics NPLs, efficiency and capitalization are related in several ways, as Berger and DeYoung (1997) also show in their research. Firstly, even though there are differences, NPL and efficiency are related because numerous of studies found that banks face potential failure have high ratios of NPL, also have low measured efficiency (Barr et al., 1994; Berger & Humphrey, 1991; DeYoung & Whalen, 1994; Wheelock & Wilson, 1995). In

addition, some studies of Kwan and Eisenbeis (1996) and Resti (1996) found a negative relation between efficiency and NPLs under banks that do not fail which relates to X-inefficiencies. According to Berger and DeYoung (1997) inefficient banks could have NPL problems because of; 1) poor senior management that have problems with monitoring cost and loan customers, and 2) loan quality problems because of exogenous events, such as stabilising economic growth whereas extra cost are associated with NPL (e.g. monitoring, workout arrangements, diverted senior managerial focus). Berger and DeYoung (1997) found there is indeed a relation between NPLs and efficiency which emphasizes the relationship between asset quality and efficiency through management quality and external events which can have a negative effect on efficiency. In addition, Peristiani (1997) and DeYoung (1998) found that efficiency is positively related to ratings of a banks' management quality. Thereby concluding that there is a relationship between asset quality and management quality. Furthermore, Hughes and Mester (2008) ad that the environment can also have influence on NPLs, for example, different accounting principles, different regulation, and other market environments are factors who can have substantial impact.

Secondly, NPL ratios and capital adequacy ratios – i.e., equity to total assets ratio – are seen as the most common risks for efficiency of banks when studying literature about variables. Berger et al. (1993), Mester (1996), C. Chang (1999), Hughes (1999), Pastor (1999), Hughes et al. (2001), Hughes, Lang, Mester, and Moon (2000), Altunbas et al. (2000), Drake and Hall (2003), Girardone et al. (2004), T. C. Chang and Chiu (2006), Chiu et al. (2008), Chiu et al. (2011), Chiu and Chen (2009) showed that by incorporating endogenous risks such as NPL directly into production or cost relationships that these risks have the biggest influence on efficiency estimates. These studies want to control for extra costs associated with NPL and/or control for underwriting and monitoring costs that influence loan quality. Thereby they showed that NPLs decreased efficiency and there is a negative relation between efficiency and NPL of banks that do not fail. Furthermore, they concluded inefficient banks frequently go together with low ratios of capital and high ratios of NPLs. To improve the estimation of bank efficiency, this study tries to test the relationship between operating efficiency and NPLs and attempts to give a comprehensive overview of the factors influencing NPLs and operating efficiency.

2.3 Non-performing loans and determinants

The definition for NPLs is adopted from the International Monetary Fund by Bloem and Freeman (2005): *"A loan is non-performing when payments of interest and/or principal are past due by 90 days or more, or interest payments equal to 90 days or more have been capitalized, refinanced, or delayed by agreement, or payments are less than 90 days overdue, but there are other good reasons […] to doubt that payments will be made in full" (p.5).* This definition is in line with Dimitrios, Helen, and Mike (2016) and Ghosh (2015)[5]. The recent financial crisis has once again sparked the interest in understanding the drivers of NPLs worldwide. Euro area NPLs surpassed 5% in 2016 and increased the stress on the banks' balance sheets[6]. In comparison to 1.5% in the United States and Japan[7]. In the recent literature two factors are responsible for NPLs: country specific (i.e. exogenous) and bank specific (i.e. indigenous) factors. Firstly, the macroeconomic (i.e. country specific) factors, for example, GDP growth and unemployment rates are likely to influence NPLs. Secondly, the bank specific features such as the characteristics of the banking sector and the management choices regarding policies are expected to influence NPLs Hence, both areas are of interest for this paper, which will be elaborated in the next paragraphs.

2.3.1 Bank specific – bad management

As mentioned above, bank specific factors have influences on the ratios of NPLs. As one of the first papers, Berger and DeYoung (1997) found a relation between NPLs and efficiency including 57,655 observations of commercial banks between 1985 and 1994 in the U.S. Their research confirmed the "bad management" hypothesis – *decreases in efficiency are most of the time followed by higher ratios of NPLs, proof that "bad management" are not only manifested in additional expenditures but also in below level underwriting and monitoring practices that lead to higher levels of NPLs (Berger & DeYoung, 1997).* Their research is followed by many other scholars. The most recent literature will be pointed out below.

Looking at the EU region, Messai and Jouini (2013) examined 85 banks in Italy, Spain and Greece, respectively. The research indicates similar findings of bank specific factors influencing NPLs supporting "bad management". Furthermore, they also found ROA has a negative effect on NPLs. Furthermore, Espinoza and Prasad (2010) found a significant relation

[5] Definition of NPLs are also in line with Bloomberg.
[6] Information retrieved from European Parliament on June the 6th 2017.
[7] Information retrieved from World Bank on June the 6th 2017

between operating efficiency – measured as non-interest expense divided by total assets – and NPLs, supporting "bad management". Williams (2004) examined a sample of EU banks, including Denmark between 1990-1998 and found evidence for a causal relation between NPLs and efficiency. Worth mentioning, he surrogates NPLs with loan loss provisions. Moreover, Fiordelisi et al. (2011) researched a large sample of EU banks, using Granger-causality techniques in a panel data framework. They find that decreasing efficiency increase banks future risk (measured in NPLs), thereby supporting "bad management".

Looking at country analyses in the EU region, Louzis et al. (2012) also found support for "bad management". He found that bank specific factors such as, efficiency and performance indicators influence NPLs in the Greek banking sector. Although, he concluded the macroeconomic variables have a more stronger effect on NPLs which is in line with "bad luck". Moreover, Podpiera and Weill (2008) did a panel study for Czech banks and investigate the causality between NPLs and efficiency of banks in emerging markets. They use an efficiency frontier using input prices of labour, capital and funds. For output variables, they used total loans and investment assets. The findings show lower efficiency is fostered with higher NPLs and thereby owing to the importance of bank failures.

In South-America, Tabak et al. (2011) used a Granger-causality method to research the relation between bank efficiency and defaulting loans in Brazil. They find a significant relationship between bank efficiency and NPLs and consider decreases in efficiency as the main trigger for the increase in NPLs. Furthermore, when banks maximize their profits they reduce the cost of loan monitoring and control to create short term efficiency. As a consequence, in the long term defaults rise and the banks' efficiency decreases (Tabak et al., 2011). Concluding, after examining the most relevant literature, many studies found evidence for "bad management" which influences the NPLs because of poor management.

2.3.2 Banks specific - skimping

Secondly, this paper must also comment an alternative hypothesis which predicts a positive sign between operating efficiency and NPLs, the skimping hypothesis. Berger and DeYoung (1997) and Reddy (2011) found that the "skimping" hypothesis was in favour for a subsample of banks that were continuous efficient over time – *increases in measured operating efficiency normally lead to higher ratios of NPLs, suggesting banks intentionally make short run cost reductions for long-run decreases in loan quality.* Several studies did not find support for the

hypothesis, which suggest higher efficiency leads not to increasing NPLs at the most efficient banks (Reddy, 2011; Williams, 2004).

2.3.3 Country specific – bad luck

Thirdly, in the literature of determinants for NPLs some models are considered as the basic linkage to NPLs. Bernanke (1989) and Nobuhiro (1997) link the financial accelerator theory to NPLs in a macroeconomic environment because these models deal with business cycles in relation to financial intermediation. In the second place, the determinants of NPLs can also be linked to for instance life-cycle consumption models of Lawrence (1995) who discusses the likelihood of default. In summary, these kind of models suggest that debtors with below average wages have a considerable higher chance to not meet their obligations because of the higher risks in relation to unemployment (Ghosh, 2015).

To explain the features of NPLs much research has been done worldwide to determine what kind of bank specific factors influence NPLs. Berger and DeYoung (1997) are seen as one of the first who began testing four management-related hypotheses regarding the relationship among loan quality (i.e. NPLs), efficiency and bank capital in the United States. One of the relations they found was "bad luck", which explained a part of NPLs – *increases in NPLs due to external events (e.g. closing of plants) are followed by decreases in efficiency, proposing high levels of NPLs cause banks' to spend more on operating costs, such as monitoring of borrowers and workout arrangements*. The finding implies that banks failures partly caused by external events and that policy and regulation could reduce this risk, such as higher capital ratios to reduces external shocks, limits on loan concentration etc. In recent literature, Reddy (2011) found similar findings in country analysis. He studied the management behaviour in other regions, more specifically in Indian banks and found significant support for "bad luck", but also for "moral hazard" and "bad management" (Reddy, 2011).

Furthermore, in the European union (henceforth EU) considerable research has been done regarding NPLs. Rossi et al. (2005) researched managerial behaviour and efficiency in central EU countries and substitutes NPLs with loan loss provisions. They found evidence for external events influencing efficiency and thereby supporting "bad luck". Comparable research of Klein (2013) used bank level data of sixteen EU countries and found both bank specific as well as macroeconomic factors influencing NPLs. He finds that the macroeconomic factors, such as higher unemployment, exchange rate depreciation and inflation lead to higher ratios of NPLs. But the explanatory power can be considered low for this kind of studies. In addition,

Škarica (2014) found results while exploring macroeconomic factors affecting NPL with data of seven EU countries. The findings suggest that both unemployment and inflation rates increase the growth of NPLs while a real GDP growth has a negative effect. Another research conducted by Jakubík and Reininger (2013) examines the causes of NPL in nine EU countries, where they found real GDP growth reduce NPLs. Moreover, in the Euro area, Makri, Tsagkanos, and Bellas (2014) concluded on a sample of fourteen countries both macroeconomic (e.g. unemployment, public debt and annual percentage growth rate of GDP) and bank specific factors influence NPLs. In addition, Messai and Jouini (2013) find evidence in the EU region that NPLs are reducing economic growth and provability, while unemployment ratios, interest rates and poor credit quality positively effect NPLs for banks in Italy, Greece and Spain.

Looking more closely to country analyses in the EU, Louzis et al. (2012) studied the nine biggest banks in Greece between 2003 – 2009. He found NPLs are mainly affected by macroeconomic variables of consumer, business and farm loan categories. In addition, Salas and Saurina (2002) researched Spanish commercial and savings banks between 1986 and 1997 and found a negative relationship between GDP growth and NPLs. In Turkey, Macit (2017) examined the fifteen largest banks using quarterly data from 2005-2010. He concluded, both macroeconomic and country specific factors influence NPLs. Macroeconomic factors as unemployment, inflation and US debt increase NPL, whereas higher GDP growth in income per person decreases NPLs (Macit, 2017).

Moreover, examining worldwide studies, Beck, Jakubik, and Piloiu (2013) investigates the influence of macroeconomic indicators in 75 countries (between 2000-2010) and found real GDP growth as main factor negatively influencing NPLs. Furthermore, they found exchange rate depreciation, drops in stock prices and increasing lending rates increase NPLs. Similar research of Espinoza and Prasad (2010) in the Gulf Co-operation Council region[8] show both macroeconomic as bank specific factors influencing NPLs – higher real non-oil economic growth (also GDP) and interest and risk aversion decreases, NPLs decrease. These findings are consistent wih Nkusu (2011).

In summary, linking the reviewed literature, a shared finding is that NPLs are reacting opposing to overall country specific macroeconomic conditions and trends in both specific country and worldwide samples. One clear finding is however, that NPLs are influenced by

[8] Member states of the Gulf Co-operation Council region are Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and United Arab Emirates.

endogenous events as the studied literature expressed, which can be interpreted as "bad luck" events.

In short, both country- and bank specific factors – i.e., "bad luck" and "bad management", respectively – seems to influence NPLs. In particular the "skimping" hypothesis is not in favour in the reviewed literature. Hence, it is expected this paper will find similar results in the sample of the banking sector. However, it is important to consider there could be other less explored causes influencing NPLs in the commercial banking sector, elaborated in the next sections.

2.4 Capitalization – moral hazard and regulation

On the other hand, this study investigates the relation between NPLs and capitalization, as it could be an alternate explanation for NPLs. Since it is a typical problem is that banks are taking unnecessary risk when other parties bear the risk, also called "moral hazard" (Berger & DeYoung, 1997). Hence, these banks are more willing to allow more risky loans, as a consequence NPLs will increase. In addition, this study tests an extra relation between NPLs and capitalization named as the "regulation" hypothesis as it tests the effects of Basel III.

2.4.1 Capitalization – Moral hazard

A definition of "moral hazard" according to Spence and Zeckhauser (1971) is: "moral hazard" occurs if on the one side actions are unobservable, and the consequences, on the other side are observable. Some sort of the same definition is adopted by Mirrlees (1999) who states: *"[moral hazard arises when there is][…] uncertainty about the outcome of people's actions, the actions being themselves unobservable though the outcomes are observable." (p.4).* This paper adopts the definition from Mirrlees (1999) as it is more comprehensive. According to Berger and DeYoung (1997) banks with low capital ratios respond to "moral hazard" incentives by increasing riskiness of their loan portfolios, which results in higher NPLs in the future. Moreover, managers could have incentives to take more risk than optimal (Zhang, Cai, Dickinson, & Kutan, 2016). For this reason, this study will follow the reasoning of Berger and DeYoung (1997) that capitalization should be examined because: "*the effects of measured cost efficiency on NPLs could be biased if the potential effects of capital were neglected*" *(p.854).* In the work of Jensen and Meckling (1976) there are two kinds of "moral hazard" issues who can cause these problems: 1) when managers pursue their private benefits and invest in these projects, or 2) from a conflict of interest between shareholder/manager and creditors.

Shareholders want to have risky loan portfolios (e.g., higher interest rates on loans), but move the risk to the depositors. Both of the "moral hazard" problems lead to increasing loan growth and higher ratios of NPLs. An explanation for "moral hazard" of Duran and Lozano-Vivas (2015) could be because of when a bank defaults, most of the losses will be saddled by debt holders, while stakeholders have limited disadvantage. Therefore, shareholders favour more risky assets with higher returns.

As pointed out, "moral hazard" is not directly observable in the banking sector, but can be observable when looking at bank behaviour. One of the main indicators of "moral hazard" problems is excessive risk taking in lending (Foos, Norden, & Weber, 2010; Zhang et al., 2016). In literature, several researchers tried to examine "moral hazard" problems. Therefore, several studies will be reviewed. The research of Foos et al. (2010) on a sample of U.S., Canada, Japan and EU banks show that loan growth lead to increases in loan loss provisions and NPLs causing a decline in interest income and capital ratio.

Looking more closely to the EU, Duran and Lozano-Vivas (2015) examined a sample of banks in the first fifteen EU countries between 2002-2009, to analyse the risk shifting problem in a regulation setting to evaluate if the Basel regulation has the preferred effect. First, they found that Basel II has a limited ability to weaken "moral hazard" incentives. Secondly, deposit insurance strengthens the incentives of low capitalized banks to transfer risk to depositors. Finally, incentives for a bank to have capital ratios above legal minimum seems to disincentive them from relocating risk to creditors. Thus, banks with more capital buffers are more mindful to risk shifting.

A study of Nier and Baumann (2006) examined a sample of thirty-two developed countries between 1993-2000 worldwide whether market discipline[9] is efficient in providing incentives for banks to limit their risk through holding more capital against adverse outcomes in portfolio risk. Banks are more likely to involve in "moral hazard" because of the government safety nets and the chance of default is minimal. This results in lower capital buffers, but on the other side stronger market discipline resulting from unsecured liabilities and disclosure results in increasing capitalization. In addition, Boyd and Graham (1998) found similar results.

Koudstaal and van Wijnbergen (2012) researched US banks and looked to the relation of excessive risk taking and capital structure. For interest of this paper, they found that banks with more distressed portfolios take more risk resulting in higher ratios of bad loans – i.e.,

[9] With market discipline banks disclose the risks associated to their risk profiles, in this case investors can see the amount of risk these banks take, and eventually penalize them (Nier & Baumann, 2006).

NPLs. Furthermore, Bernanke; and Gertler (1986) found that bank managers and shareholders have incentives to shift the risk when NPL ratios are becoming too high. In addition, Eisdorfer (2008) examined a large sample of U.S. financially distressed firms and showed that managers of these firms have incentives from shareholders to shift risk to bondholders, which implies "moral hazard" problems.

Looking at other regions, Niinimaki (2012) analysed if hidden bad loans worsen the "moral hazard" problem between banks and supervision. He found the problem occurs and cannot be solved with diversification. The bank tries to hide bad loans by e.g. approving new loans to meet the obligations of the old loans. Hence, the bank seems profitable, but actually have large amounts of problem loans. Furthermore, Zhang et al. (2016) researched the relation between NPLs and capitalization for Chinese banks. They found evidence for banks who are facing high ratios of NPLs resulting in "moral hazard" behaviour: "*banks' excessive risk-taking would temporarily relieve the problem but cause greater losses in the long run" (p.58).*

In closing, literature found significant results that low capitalized banks can be a determinant for increasing NPLs. In general, banks are mainly operating for their own interest and not in the benefit of shareholders. Hence, this study includes "moral hazard" because it could explain why banks management behave in a certain way when NPLs are increasing.

2.4.2 Capitalization – regulation

In the following section the Basel regulation and empirical results will be elaborated. In 2008 the financial crisis showed how fragile the financial system is. One of the measures to tighten regulation and to minimize chances of mishaps occurring again – the supervision framework for banks – Basel III is introduced. This version of Basel, is a more tighten version of Basel II and should prevent banks taking on liquidity risk and improve the ability to absorb shocks from financial and economic stress (Cosimano & Hakura, 2011; Koudstaal & van Wijnbergen, 2012). Furthermore, the new regulation tightens the definition of bank capital and entails banks to hold higher quantities of capital for a given quantity of assets[10].

Much research has been done about the debate of Basel regulations. One side of literature reasons there are significant macroeconomic benefits when raising bank equity

[10] More specific, banks need to hold a minimum of 4.5 percent equity tier 1 and buffers which limits dividend pay-outs (BIS, 2010a and 2010b). The latter suggests a bank holding company (i.e. controls one or more banks) is exposed to risk-weighted asset ratio (also known as capital adequacy or CAR) between 7-9.5 percent over the credit cycle.

because higher capital ratios lowers leverage and the risk of bank failures[11]. On the other side literature argues there could be high cost associated when implementing higher capital requirements (Angelini et al., 2015; Beck et al., 2013; Beck, Demirgüç-Kunt, & Maksimovic, 2004). The higher capital requirement could lead to higher lending rates and slow down loan allowances and economic growth (Cosimano & Hakura, 2011). In addition, Rime (2001) researched a sample of Swiss banks and argues the motivation for regulations in capital requirements are because of banks hold less capital than socially optimal in relation to their riskiness. He explains this relation with the argument that banks in practice would never hold more capital than is required by e.g. the Basel committee. Furthermore, he analysed how banks would react on the regulation and found banks close to the minimal capital requirements increased capital ratios, concluding the penalties for not meeting the requirements has the wanted result on the banks behaviour (Rime, 2001).

Furthermore, similar regulation as Basel is examined by Jacques and Nigro (1997) a few decades ago. They tested the impact of, back then, recently implemented risk-based capital standards on US bank capital and portfolio risk. The risk-based capital standards indeed had a significant positive sign on capital ratios and negative sign on portfolio risk for banks who encountered the new regulation. Furthermore, banks with capital ratios slightly below the standard, experienced relatively large increases in capital ratio by e.g. raising capital, while banks severely undercapitalized experienced relatively small increases (Jacques & Nigro, 1997). Thus, these findings suggest the regulation for heavily undercapitalized banks does not work.

Barth, Caprio, and Levine (2004) conducted a cross-country research over 107 countries to measure the relation between regulation and sector development. One of the results they find is that strict capital regulations are negatively related to NPLs (Barth et al., 2004). These findings imply that when regulators are more focused on higher capital ratios, NPLs decrease and the proposed regulation has the desired effect.

In conclusion, regulations on for example capital adequacy is ended on decreasing risk and secure the financial markets. Despite there is not much research done in this field, the literature suggests the regulation displays mixed results of how effective these actions are. For this reason, it is interesting for this study to test the proposed regulation of Basel III.

[11] See Admati, DeMarzo, Hellwig, and Pfleiderer (2013).

2.5 Formulated hypotheses

After an extensive literature review, this section will formulate the hypotheses that will be tested in this study. Figure 1 below illustrates the constructs and variables measured in this study in the context of the studied variables: 1) NPLs, 2) operating efficiency, and 3) capitalization in commercial banking. The variables are gradually dependent with their own intervals and other lagged variables. Furthermore, the signs of the "bad management", "skimping", and "bad luck" hypotheses are reversed in comparison with the most studies reviewed due to the measure of operating efficiency. Because a higher ratio implies lower efficiency, as in other studies a higher ratio means a bank is more efficient. The relations between the variables are intertemporal, since literature pointed out. As mentioned before, the signs are expected to be different between the constructs. In this setting, it is possible to test multiple relations with the same variables. The five hypotheses are formulated below and partially adopted from Berger and DeYoung (1997).

Firstly the "bad management" hypothesis is defined as – low efficiency is a sign of poor senior management performance and therefore Granger-cause higher NPLs. The poor management is caused of e.g., inadequate credit rating and incompetent collateral rating as a consequence the loans with negative net present values will increase (Berger & DeYoung, 1997; Louzis et al., 2012). The expected sign of the relation is negative between NPLs and operating efficiency. Therefore, the following hypothesis can be defined:

> **H1**: *low operating efficiency has a positive influence on increasing non-performing loans of commercial banks*

Secondly, the "skimping" hypothesis is tested in the same order as "bad management" only the sign is reverse, it suggests a negative Granger-causation from operating efficiency to NPLs. Thus, higher measured operating efficiency is implied with a negative Granger-causation to NPLs. The negative sign is caused by a trade-off between operating cost and the future performance of the loans (Berger & DeYoung, 1997). Banks maximize their long-term profits by cutting in short term costs. The amount of resources used for e.g. underwriting, monitoring loans and assessing collateral are reduced which makes them more efficient in the short term. As a consequence the quality of the loans in time becomes worse and NPLs increase (Williams, 2004).

H2: *Higher operating efficiency has a negative influence on non-performing loans of commercial banks*

Thirdly, in the "bad luck" hypothesis it is expected that an increase in NPLs forego or Granger-cause decreases in operating efficiency (Berger & DeYoung, 1997). The increases in NPLs are triggered by external events e.g. unemployment because of bankruptcy of firms. Furthermore, macroeconomic factors such as reductions in GDP growth or interest rate drops can increase the NPLs ratios (Williams, 2004). Banks therefore put extra managerial effort in loan management when they are past due. With these efforts additional expenses are involved like monitoring defaulting borrowers, examining possible workout agreements, cost conserving and seizing, and finally disposing security and the cost of the extra precautions that have to be arranged to assure the quality of the loans. Somehow the same relation is predicted as in "bad management", but the dependent variable is opposite.

H3*: Increasing non-performing loans are positively associated with lower operating efficiency of commercial banks*

Fourthly, the reviewed literature points out that "moral hazard" is a problem within banks – *banks are taking disproportionate risk on behave of shareholders to shift the risk more to creditors.* Especially banks with low capital respond to moral hazard incentives by aggregate the risk of loans. Therefore, banks are more willing to accept loans with higher risk, because of higher returns. Moreover, these banks have less capital to lose in case of default. In other words, low capital results in management taking more risk in their loan portfolios. So there is a negative relationship between increasing NPLs and declining capitalization of the banks (Berger & DeYoung, 1997). Based on the latter, the hypothesis for this study is defined as follows:

H4: *Low capitalized commercial banks have a negative influence to increasing non-performing loans*

Finally, to add a new aspect, this paper tests the "regulation" hypothesis. The Basel regulation has the purpose to hold an amount of capital in alignment with portfolio risk (Jacques & Nigro, 1997). If not, banks could hold less capital than is optimal in relation to the riskiness

(Rime, 2001). The Basel regulators specified that banks that have more risky loans, need more capital and with Basel III banks are encouraged to have even more capital buffers. Altunbas et al. (2007) described in their work the so called "regulatory" hypothesis", which states that regulators boost banks to increase capital in relation with the volume of risk engaged. Hence, this study adopts a sort of the same hypothesis – there should be a positive relation between NPLs and capitalization:

> **H5**: *Increasing non-performing loans have a positive influence on capitalization of commercial banks*

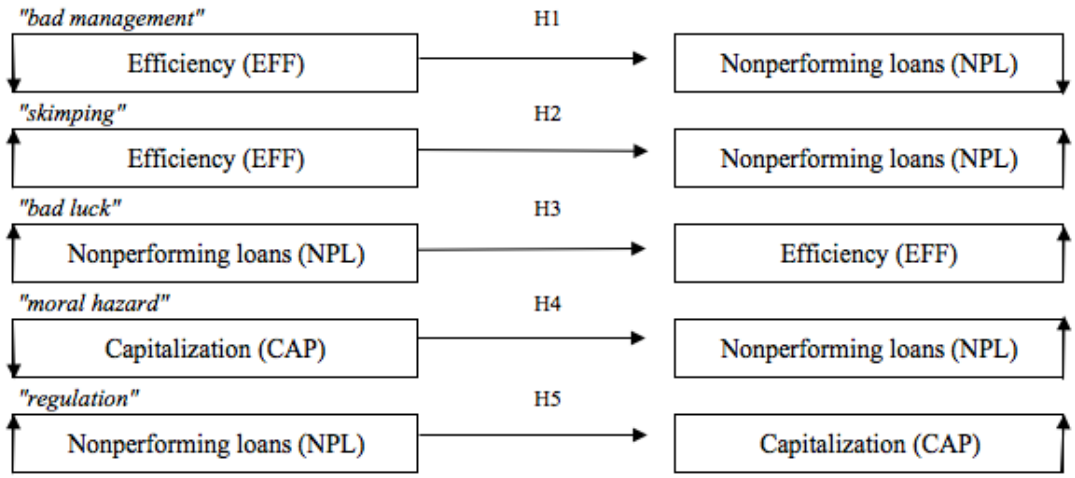

Figure 1 Theoretical model. Arrows in the left box of "H1" means when for instance, NPL increases, EFF decreases.

3. RESEARCH METHOD

Quantitative panel data is estimated using a vector autoregeression (VAR) methodology and a Granger-causality test is performed to answer the main research question. As the goal of this research is to determine the effects of NPLs, efficiency and capitalization in relation with management behaviour and/or external events. Data from Bloomberg will be used to collect data of thirty commercial banks worldwide and in the EU. This section will elaborate on the procedure, research design, sample size and sample selection, measures, data collection and data analysis.

3.1 Procedure and design: panel data techniques

In finance, and more specifically financial modelling, there are three main data types for quantitative analysis namely: time series data, cross-section data and panel data (Brooks, 2014). This study examines panel data i.e., longitudinal data, because the research analyses both time series and cross-sections with a panel regression. This approach is consistent with e.g. Berger and DeYoung (1997) and Podpiera and Weill (2008). Overall, most of the techniques and analyses used in econometrics are similarly effective for time series and cross-section data (Brooks, 2014). Important, the difference between cross section and panel data is that cross section is based on random samples over time, and panel data is based on same units over time and measure a sort of quantity about it over time (Brooks, 2014).

Econometrically, the basis used for any panel data is described as follows:

$$Y_{i,t} = \alpha + \beta x_{i,t} + u_{i,t} \ (\mathbf{1})$$

In the equation Y is the dependent variable and x is the independent variable, a the intercept, β is a * 1 vector of parameters to be predicted on the explanatory variables, and u is the error term. Moreover, *it* is the vector of 1 * k of observations on the explanatory variables and defines what cross-sectional unit *i,* and what time *t*. Thus, *t* stands for time series observation and *i* for cross-sectional component (Baltagi, 2011; Brooks, 2014).

3.1.1 Model to estimate panel data: vector autoregression

First of all, this study is based upon the framework of Berger and DeYoung (1997) in their study to US banks. Many other scholars followed the same approach, which will be discussed later. Furthermore, this paragraph will eloborate in detail the steps to conduct the analysis. To begin with, the study applies a VAR methodology. With this method, it is possible to predict the relations between NPLs, operating efficiency and capitalization using ordinary least squares (OLS). The VAR model is first described by Sims (1980) and is since then frequently used in econometric modelling studies. For instance, Espinoza and Prasad (2010) and Williams (2004) conducted similar studies in this particular field using the same method. Furthermore, a VAR model is useful to assess the scale and length of the effects researched, particular with this type of study as Klein (2013) showed. A VAR model is able to include more than one independent variable – i.e., a systems regression model. VARs are seen as an *"alternative to large-scale simultaneous equations structural models*" (Brooks, 2014) p.290. The technique treats all the variables as endogenous in combination with panel data (Brooks, 2014; Klein, 2013). The advantage of this technique is that researches do not have to specify which variables are endogenous or exogenous (Klein, 2013). A second advantages is that the forecast made by VARs are often better estimated than traditional models. For example, McNees (1986) tested variables and concluded the forecast are more accurate when using VARs. However, a limitation of VARs are the way to decide the optimal lag length (Brooks, 2014). Another limitation is that all the data should be stationary to test the statistical significance of the coefficients (Brooks, 2014). But, supporters of VARs are arguing that differencing leads to loss of information between variables (Brooks, 2014).

In order to analyse the equations (2) – (4), formulated in the next section, this study applies Granger-causality tests, initially used by Berger and DeYoung (1997). Which other scholars have proven to be successful in studies about NPLs, efficiency and capitalization (Espinoza & Prasad, 2010; Podpiera & Weill, 2008; Reddy, 2011; Rossi et al., 2005; Williams, 2004). With the Granger-causality test, it is possible to determine if the intertemporal causality/relation between NPLs, operating efficiency and capitalization are significant. The Granger-causality test is a F-test – i.e., Wald test – which is first described by Granger (1969) and later a variant of it by Sims (1972).

Moreover, the variables in the Granger-causality technique are tested with other independent variables, but also with their specific lagged values. Thus, the Granger-causality system tests in both directions for the dependent variable (Granger, 1969). More specifically,

the equations (2) – (4) display that each dependent variable is regressed on annual lags of it and the two other variables. For example, based on equation (2), a significant relation between operating efficiency and NPLs implies that operating efficiency is Granger-causing NPLs, if NPLs can be better predicted using the past values of both NPLs and operating, then by using only the history of NPLs alone. In other words, the level of NPLs and operating efficiency in period (s) *i* Granger-cause NPLs in year *t*. However, when the *X* variables are Granger-causing Y, the summed coefficients should be significant in the equation of Y to prove the effect (Granger, 1969). In short, the sum of the coefficients measures the total effect of the independent variables on the dependent variables and the Granger-causality test proves if it statistically significant. Finally, causality in a Granger-causation means that there is a correlation among the current value of one variable and the past values of other variables, it does not imply a movement of variable X cause a movement in variable Y (Brooks, 2014).

3.2 Implementing the model

When testing for Granger-causality it is vital to define the optimum lag length as described before (Brooks, 2014). For instance, Williams (2004) showed that certain relations between variables became insignificant due to including more lags. This paper uses a three-year lag model. The decision is based upon several concerns. Firstly, a higher number of lags is wanted to identify the effects of operating efficiency on NPLs, because the loan quality and thereby the process to allowance of loans is normally measured with an interruption of several years. Secondly, this paper performed a F-test, which is proposed by Reddy (2011) and Williams (2004) who performed comparable research. By increasing the number of lags, the ideal lag length can be recognised through the change in f-statistic and testing the significance of coefficients (Reddy, 2011). When testing the coefficients with the three lagged and four lagged model the results were most optimal and significant[12]. Besides, previous papers have shown significant results using a three- or four year lagged model (Berger & DeYoung, 1997; Podpiera & Weill, 2008; Williams, 2004). Finally, using more lags has the consequence there will be less observation, which can lead to loss of information (Brooks, 2014). In addition, the degrees of freedom are increasing and F-statistic decreases what makes the results less significant as Espinoza and Prasad (2010) concluded.

[12] In appendix A the F-values are given.

Before the model is tested the study checked for multicollinearity which exist if two independent variables are highly correlated and increases the stand error which influences the T-statistic (Brooks, 2014). The variables capitalization and RWA show a correlation above 0.70. However, the high correlation between capitalization and RWA is possibly explained because regulators demand that banks with certain portfolio strategies should have higher capital ratios (Berger & DeYoung, 1997)[13].

The data is tested for unit root i.e. stationary data with the Dickey and Fuller test, as for instance, discussed by Espinoza and Prasad (2010) and Klein (2013). According to Brooks (2014) stationary data can be defined as; *"one with a constant mean, constant variance and constant autovariance for each given lag" p.318.* If the data is not stationary it can lead to spurious regressions and show significant coefficients and a high r^2, but in reality the variables are not related (Brooks, 2014). Dickey and Fuller (1979) developed a method to test for stationary data, where the null hypothesis imply series contain a unit root and are non-stationary and wherein the alternative hypothesis means the data is stationary. Testing the sample with the Fisher-ADF test, I found non-stationary data for CAP and CAP-EU[14]. To solve this problem and forego spurious regressions I tested with first difference suggested by Espinoza and Prasad (2010) and was able to reject the null hypothesis. To implement the data in the model, CAP and CAP-EU are recoded following Brooks (2014) with the formula:

$$\Delta x_t = x_t - x_{t-1}$$

Since the recoding can lead to loss of information, this study will follow the proposed approach of Klein (2013) and Espinoza and Prasad (2010) and estimate multiple models which include CAP and CAP-EU variables in both level and first difference. Wherein level difference functions as a robustness test, discussed in section 4.

In summary, to perform the analyses this study applies a VAR model which uses individually OLS estimates for the equations using a three-lagged model on the right-hand-sided variables. Furthermore, to confirm the outcomes for equation (2) – (4) a Granger-causality test is performed to indicate if the data is consistent with the five hypothesis who are predicted by the relationships between NPLs, efficiency and capitalization. As discussed by Sims (1980) a VAR should be unrestricted by using the same lags for all the variables. Furthermore, the

[13] In appendix B the correlation matrix can be found.
[14] In appendix C the test results can be found

number of observations depends on the number of lags included. With three lags, which is the most optimum, there are 168 observations left. In the equations (2)- (4), the dependent variables are on the left-hand side as well with the lagged value and other lagged explanatory variables on the right hand-side.

Equation (2) will analyse the "bad management", 'skimping" and "moral hazard" hypotheses, wherein NPLs is considered as the dependent variable. "Bad management" predicts a positive sign, however, a negative sign predicts "skimping" behaviour. As discussed in previous sections, "skimping" is most likely observable under the most efficient banks. Therefore, equation (2) is re-estimated for a sub-sample of the most efficient banks. In closing, "moral hazard" is expected to occur under banks who have low capital buffers, therefore, equation (2) analyses also a sub-sample of thinly capitalized banks.

Equation (3) is testing the "bad luck" hypothesis. The sign of the relation between the dependent variable operating efficiency (EFF) and NPLs is expected to be positive.

Finally, in the work of Berger and DeYoung (1997) equation (4) is added to complete the model wherein capitalization (CAP) is the dependent variable. Following Berger and DeYoung (1997), Reddy (2011), and Williams (2004) this paper expects to find a negative sign between NPLs and capitalization, and also a negative sign between operating efficiency and capitalization. Although, these predicted relations cannot be assigned to any of the four hypotheses. These results could suggest that NPLs and inefficiencies are related with reductions in capital (Berger & DeYoung, 1997; Williams, 2004). In addition, this study includes the "regulation" hypothesis. The relationship predicts a positive sign between NPLs and capitalization. The equations are acquired with E-views, which is an econometrical statistical program for automated data analysis[15]. The equations in the Granger-causality framework are presented as follows:

$$NPL_{i,t} = f(1)\left(NPL_{i,lag}, EFF_{i,lag}, CAP_{i,lag}, GDP_{i,lag}, RWA_{i,lag}, YEAR_t, , REGION_t\right) + \varepsilon 1 i_t \quad (\mathbf{2})$$

$$EFF_{i,t} = f(2)\left(NPL_{i,lag}, EFF_{i,lag}, CAP_{i,lag}, GDP_{i,lag}, RWA_{i,lag}, YEAR_t, , REGION_t\right) + \varepsilon 2 i_t \quad (\mathbf{3})$$

$$CAP_{i,t} = f(3)\left(NPL_{i,lag}, EFF_{i,lag}, CAP_{i,lag}, GDP_{i,lag}, RWA_{i,lag}, YEAR_t, , REGION_t\right) + \varepsilon 3 i_t \quad (\mathbf{4})$$

[15] Retrieved from E-Views June 20, 2017

Where:

$NPL_{i,t}$ = Non-performing loans for bank *i* in year *t*

$EFF\ (1)_{i,t}$ = Operating efficiency for bank *i* in year *t*

$CAP_{i,t}$ = Capitalization for bank *i* in year *t*

$GDP_{i,t}$ = Gross domestic product per capita for bank *i* in year *t*

$RWA_{i,t}$ = Risk-weighted assets for bank *i* in year *t*

$YEAR_t$ = Set of time dummy variables

$REGION_t$ = Set of region dummy variables

$\varepsilon 3_{i,t}$ = The error term, or residuals.

Furthermore, a set of time dummy variables ($YEAR_t$) is included to test for shocks for each year inter alia controls for changes in the environment like falling interest rates and regulatory changes such as those emanating from EU financial deregulation as well as changes in technology. The YEARt dummy is included for all the years, with exclusion for the base year. Each dummy is equal to one, if the observation refers to the correspondent year and zero if otherwise. This is the same approach as Berger and DeYoung (1997). Furthermore, because of the first differencing for non-stationary series, and the three year-lag model, it was only possible to include dummies for the last five years (2012-2016). As a consequence, the total number of observations included in the model decreased. Secondly, we have a dummy variable for the REGIONt. Because there is a chance there are differences between EU and the full sample because of regulation and macroeconomic differences see for instance Hughes and Mester (2008). Also, a number of control variables are added to all the equations. Firstly, risk-weighted assets (RWA) also used by Berger and DeYoung (1997) is included. RWA is involved because some of the portfolios will produce more NPLs, as low measured efficiency might reflect the cost related to banks with more loans on their balance sheet, and because financial markets and bank regulators could force banks with certain loan portfolios to have higher capital buffers (Berger & DeYoung, 1997). Furthermore, gross domestic product per capita (GDP) is included to control for the influences of GDP on NPLs, since several researcher have shown GDP growth leads to decreasing NPLs, see for instance Beck et al. (2013) and Makri et al. (2014). This paper has chosen for GDP per capita because these data was one of the few

datasets that was complete for all the countries in the sample[16]. The GDP data was retrieved in US Dollars and is recalculated to EURO.

Finally, to test for differences in the EU this paper made several dummy variables; EFF-EU, NPL-EU, EFF1-EU, ROA-EU and CAP-EU. The dummies where calculated by multiplying for example EU * EFF. This approach has the advantage that all the test can be estimated in one run.

3.3 Measuring bank efficiency

Efficiency can be measured in several ways, the two most used approaches are: 1) the frontier approach, and 2) individual financial ratios. The frontier approach is used by many scholars and seen as the most popular method for measuring efficiency of banks see (Guzman & Reverte, 2008; Liang, Yao, Hwang, & Wu, 2008; Lin, Hsu, & Hsiao, 2007; Paradi, Vela, & Zhu, 2010; Van Der Westhuizen, 2010). The input and output factors, mostly financial ratios, are used in the frontier method and transferred to a single measure of efficiency, which lies between 0 to 1, where 0 means inefficient and 1 efficient (Van Der Westhuizen, 2013). There are non-parametric – e.g., Data Envelopment Analysis – and parametric – e.g., stochastic frontier approach – frontiers. The non-parametric approach assumes there is no random error which may cause problems with the accuracy of the frontier. Parametric frontiers, or thick frontier allow for random error (Van Der Westhuizen, 2013). In literature there is no direct better estimation, but the solution between the models is to add more flexibility in the parametric approaches and introducing a degree of random error into the non-parametric approaches (Berger & DeYoung, 1997). Reviewing the literature demonstrates there is no significant better method when using frontier approaches, the next paragraph targets which inputs and outputs are of use to measure efficiency.

The inputs and outputs described above are used for a frontier model. Many debates have proceeded about defining a bank's inputs and outputs and how to measure the efficiency with the in- and outputs. In the work of Berger and Humphrey (1991) there are three methods analysed – 1) the asset, 2) user cost and, 3) value added methods. The asset approach uses loans and other assets as bank outputs, deposits and other liabilities are inputs for the intermediation process (Berger & Humphrey, 1991; Sealey & Lindley, 1977). Under the user cost approach, a financial product is considered an input or an output whether it contributes to the revenue of a

[16] GDP data is retrieved from World bank May 8, 2017.

bank. If the return of an asset surpasses the opportunity costs then it is considered an output (Berger & Humphrey, 1991; Hancock, 1985). A problem with this measure is that there is some commingling with implicit revenues. In resemblance, the value-added approach differs from the asset- and user cost approach because it considers that all liabilities and assets have some sort of output. Important outputs are loans and deposits, and inputs are purchased funds that require small amount of physical inputs – e.g., labour and capital. Overall, as mentioned before, measuring bank output, technical change or productivity growth is difficult, because of the confusing effects of inefficiencies over time. However, of the measures the value-added approach, in which the flows of physical labour and capital inputs are matched to banking functions, identifies the important bank outputs as being the major deposit and loan categories, is considered as the most suitable for accurately estimate changes in bank technology and efficiency over time (Berger & Humphrey, 1991). Several studies used the above described variables as in- and outputs. In the model of Berger and DeYoung (1997) they adopt a stochastic frontier approach with input factors including labour and physical capital costs, and outputs including different types of loans, transaction deposits and fee based income, which they call an operating cost function. This approach is also used by (Altunbas et al., 2007; Daley & Matthews, 2009; Rossi et al., 2005; Tabak et al., 2011). On the contrary, there are other methods to measure bank efficiency.

To understand if a bank is performing efficient only looking at the income statement is not enough. An increase in income does not mean a bank is operating more efficient (Van Der Westhuizen, 2013). A more common way to measure efficiency is to look at financial ratios, such as return on assets (i.e. ROA) or return on equity (i.e. ROE). The ratios can be applied in every industry. However, the banking sector has some specific ratios for example: 1) *non-interest income to interest income, 2) rates of growth in deposits and advances, 3) net interest income and 4) net interest margin* (O'Donnell & Westhuizen, 2002; Van Der Westhuizen, 2013). Although, there are some issues related with the performance measures. In the first place, these measures are only useful when using a benchmark. Besides, determining when a bank is observed as performing good on basis of e.g. ROA can be a problem. In the second place, performance measures only measure a small piece of all the available data of the bank. As a consequence, a bank can perform good in for example ratio of NPLs to total assets and perform bad in total cost per employee (Yeh, 1996). Financial ratios are useful indicators in every sector, but do not always measure accurately. In similar fashion, there are more frequently used ratios to measure efficiency.

Finally, a more widely used method is to measure operational efficiency with the *ratio of non-interest expense (e.g. overhead cost, IT costs) divided by operating costs* (Kovner et al., 2015). In a way similar as Espinoza and Prasad (2010) and Louzis et al. (2012). The used approach looks at individual bank level to the operating efficiency. The approach is related to banking merger literature using accounting variables to estimate the effects of the merger or acquisition, such as Kwan and Wilcox (2002) and Cornett et al. (2006). In addition, Hays, De Lurgio, and Gilbert (2009) measure efficiency as the level of non-interest expense needed to support one dollar of operating revenue, consisting of operating income (i.e. interest income + non-interest income and/or fee income).

In closing, efficiency can be measured through a frontier approach or with individual financial ratios. This study measures efficiency with the financial ratio of – *non-interest expense to operating cost i.e. operating efficiency* – based on multiple considerations: First, as mentioned before, this study adopts – *a cost function to measure efficiency instead of a production function because this paper wants to determine how cost efficient a bank is in routing funds from depositors to borrowers.* In relation with routing the funds as efficient as possible, lower non-interest expenses implies a bank is more cost efficient. Second, following the recent literature, e.g. Espinoza and Prasad (2010) and Louzis et al. (2012) use a similar operating efficiency measure to examine the relation among NPLs and capitalization. Third, several scholars showed that non-interest expenses, such as underwriting and monitoring cost influence the loan quality significantly [17]. Finally, in spite of the more popular frontier methods, the data for this method is scarce, but also more time consuming and therefore out of the scope for this study.

[17] See for instance; Berger et al. (1993), Mester (1996), C. Chang (1999), Hughes (1999), Pastor (1999), Hughes et al. (2001), Hughes et al. (2000), Altunbas et al. (2000), Drake and Hall (2003), and Chiu et al. (2011).

3.4 Data collection and description of sample

In total thirty banks are selected worldwide[18]. In the first place, data was retrieved from DataStream, although after cleaning-up the dataset, several main variables had a considerable amount of missing values. Instead, the data was manually collected from Bloomberg. As a consequence, the manual collection of data had impact on the sample size. Nevertheless, data is collected for eleven countries; Canada, China, France, Germany, Italy, Japan, Netherlands, Spain, Switzerland, United Kingdom, and United States. Annual data for all the variables is collected over a period from 2007-2016. With the current sample size, it should be possible to find significant results as previous papers showed[19]. Furthermore, the sample is restricted to ten years because of insufficient data. Also, two banks were excluded from the original sample because there were too much missing values. The banks are selected based on their total assets. Resulting in a sample of thirty largest banks worldwide, of which fifteen in the EU. All the currencies were automatically computed in EUR in Bloomberg. The result is an unbalanced panel dataset with 289 observations after clean-up. The first part of the data is analysed by means of descriptive statistics (see table 1 and 2). In the second part the model is estimated with a VAR and tested with a Granger-causality technique.

[18] Source: worldwide sample is retrieved from Statista June 2016 . European sample is retrieved from Statista 2016. Moreover, the list of included banks can be found in appendix D.

[19] In comparable studies Louzis et al. (2012) and Podpiera and Weill (2008) examine the nine largest Greek banks and 43 Czech banks, respectively.

Table 1 Distribution of data

Country	*Number of Banks*	*Total financial assets per country 2016 (mil EUR)*
Canada (CA)	1	803,121.00
China (CN)	5	12,463,500.00
France (FR)	4	6,218,672.00
Germany (DE)	1	1,590,546.00
Italy (IT)	1	859,533.00
Japan (JP)	5	7,705,569.00
Netherlands (NL)	1	845,081.00
Spain (ES)	2	2,070,979.00
Switzerland (CH)	2	1,635,729.00
United Kingdom (UK)	4	5,424,300.00
United States (US)	4	7,965,100.00
(Total =	*30)*	

Source: All data is retrieved from Bloomberg and own calculations.

Notes: All given data is for FY year 2016. Table shows distribution of total assets per commercial bank per country. Furthermore, CN is represented with the most assets per country, followed by the US, JP, FR, UK, CH, DE, IT, and NL.

3.5 Variable explanation

This section explains the various variables that are used to measure the multiple relations in this study. An overview of the variables can be found in table 2. Non-performing loans (NPLs) are measured using the proposed model of Berger and DeYoung (1997)[20] to assess the quality of loan management. To measure operating efficiency (EFF), this study adopts the measure of – *non-interest expense to total operating income*. This measure is accepted by several researchers – e.g., Espinoza and Prasad (2010), Louzis et al. (2012), Kwan and Wilcox (2002), Cornett et al. (2006), and Hays et al. (2009). The ratio tends to measure the operating efficiency of commercial banks in relation to – e.g. personnel expenses and other non-interest operating expenses. A higher ratio means higher expenses, or likewise lower efficiency. A few limitations can be recognised; firstly, the ratio can occasionally increase because of annual to annual movements in non-interest expense because when banks broaden their business because new

[20] The defined measure for NPLs is acknowledged by for instance by Bloomberg and Bloem and Freeman (2005).

personnel is needed and cost will increase. Secondly, the movements in annual to annual figures in operating income could be a problem. For instance, during the financial crisis ratios spiked for many banks, because of losses in trading and other non-interest losses. To measure the capitalization of banks (CAP) – *total equity over total assets* – is used same as e.g. Rossi et al. (2005) and Berger and DeYoung (1997). The CAP variable measures the absorbing flexibility for loan losses.

To provide a more normalized view – since the standard deviation is rather large for EFF – which is not as sensitive to the anxieties as described above this study additionally shows results based on measuring (EFF1) – *non-interest expense to total assets* – suggested by Kovner et al. (2015). Again, a higher ratio, the more inefficient a bank is. Furthermore, there are some missing values for NPLs for a few commercial banks. Most of the missing values are filled by looking in the annual reports. I expect no bias in estimation because these missing values are contained to a minimum. Finally, the measures ROA, GDP and RWA are control variables. EU and YEAR are dummy variables, as mentioned before.

Table 2 show the descriptive statistics of the variables. The mean of the NPL ratio (3%) does not show large differences with for instance Ghosh (2015) who measured 3.3% NPLs for US banks in the same time-series. The EFF efficiency measure shows large variations when observing the standard deviation. As mentioned before, the high ratios are due to spikes in operating income. The normalized EFF1 shows little variation since it is divided with total assets and is consistent with for instance Kovner et al. (2015). However, in comparison with Ghosh (2015) the ratio is slightly lower, possibly due to the different time-series he examines. The CAP ratio shows that some banks have much higher capital buffers than others. However, these figures are not that different with that of Williams (2004) for EU banks and Ghosh (2015). The ROA measure also shows large variation, again because of the spikes in income. Finally, the GDP and RWA ratios show little variation.

Table 2 Definitions and descriptive statistics

Variable	*Definition*	*Mean*	*Median*	*Std. dev. (N =289)*	*Min*	*Max*
NPL	Non-performing loans ratio = value of loans which payments are past-due for at least 90 days divided by total loans.	0.031	0.021	0.029	0.000	0.187
EFF	Operating efficiency ratio = non-interest expenses e.g. monitoring costs divided by total operating income.	1.969	2.171	26.418	-349.017	158.612
CAP	Capitalization ratio = total equity divided by total assets.	0.059	0.056	0.021	0.014	0.129
EFF1	Operating efficiency ratio 1 = non-interest expense divided by total assets i.e. normalized value for shocks.	0.017	0.016	0.008	0.000	0.050
ROA	Return on assets performance indicator = indicates how efficient management is using assets to generate earnings.	0.454	0.369	0.535	-1.594	1.523
GDP	Gross domestic product per capita = measure of total output of country, divided by number of people in country.	34.864	37.070	16.605	2.405	78.537
RWA	Risk-weighted asset ratio = ratio of total risk-weighted assets to total assets.	0.425	0.400	0.168	1.057	0.404
			<u>% Of observations</u>			
EU	European = 1 when bank is located in the EU, and 0 if not, multiplied with value of variable.		50%			
YEAR 2012 =	1 in 2012, = 0 otherwise					
YEAR 2013 =	1 in 2013, = 0 otherwise					
YEAR 2014 =	1 in 2014, = 0 otherwise					
YEAR 2015 =	1 in 2015, = 0 otherwise					
YEAR 2016 =	1 in 2016, = 0 otherwise					

Source: All numbers are retrieved from Bloomberg and own calculations. Definitions are retrieved from multiple sources described in above.

Note: Numbers are calculated for 289 observations over the years 2007-2016.

4. REGRESSION RESULTS

4.1 Testing the bad management and skimping hypotheses

The coefficient estimates of the equations (2) – (4) are observable in table 3 using three lags.

In the NPL equation (2) both the "bad management" and the "skimping" hypotheses are rejected for the full-sample, as well for the EU-sample. From these results, we can tell that EFF does not precedes NPL and that NPL is not better predicted when the history of EFF is taken into account than when it is excluded. However, the sum of coefficients of EFF on NPLs are negative and in favour of the "skimping" hypothesis. Moreover, when examining the normalized value EFF1 – as a proxy for EFF – on NPLs, the sign is positive and in favour of "bad management", however the relation is not statistical significant. When controlling with the ROA variable on NPLs, neither do the corresponding coefficients have the predicted sign, nor is it significant. As mentioned before, it can be argued that EFF and EFF1 do not fully represent operating efficiency as these measures only represent a small part of information that is effecting efficiency (Yeh, 1996). Furthermore, the control variable GDP has a negative sign and is statistically significant (10% level). The latter suggest that when GDP increases for all the lagged values with 1%, NPL decreases. This finding is not surprisingly, since when GDP is growing, the economy is also growing, and NPLs will decrease which is consistent with that of Macit (2017).

In addition, this study re-estimated equation (2) to asses if the results are robust with the first model[21]. Running the model with non-stationary data (level difference) for CAP and CAP-EU, the ROA-EU control variable is positive related to NPLs and is significant in the range of the 5% level, consistent with the "bad management" hypothesis (not shown in table). The sum of the coefficients of ROA-EU is negative which suggest when the performance indicator ROA decreases 1% for three years, the NPLs will increase with 0.00035% for EU banks, in this case the economic impact is rather small.

Based on the initial results the "skimping" hypothesis is not confirmed; however, this does not mean individual banks are not "skimping". Following Berger and DeYoung (1997), the expectation is that the most efficient banks are "skimping", meaning such banks *"face a trade-off between loan quality and cost reductions and wait for the NPLs to multiply in future*"

[21] Klein (2013) and Espinoza and Prasad (2010) suggest using level and first difference as first difference can lead to loss of information. A second robustness analyses was performed. Therefore, this study excluded all the insignificant dummies and control variables. The alternate model did not show any differences in the outcomes, suggesting the results are robust.

(Reddy, 2011) p.56. The study therefore re-estimates equation (2) for a subsample of the most efficient banks, which results in a sample of 120 observations[22]. Although, using a three-lagged model and time dummies effects the number of observations. The latter results in 56 observations, therefore only the worldwide-sample will be tested. Observed in table 4, the "skimping" hypothesis is rejected, since surprisingly the lagged coefficients of EFF on NPLs are positive and significant, which is in favour of "bad management". An increase of 1% in efficiency leads to an increase of 0.000808 over the three years in NPLs, which has a small economic impact. Next, the proxy EFF1 has a negative sign on NPLs, and is statistically insignificant. Moreover, the control variable ROA is significant under the 1% level with a positive sign on NPLs, thus supporting the "skimping" hypothesis. Implying increases in measured performance is followed by future increases in NPLs.

Finally, an additional estimation for equation (2) for the most inefficient banks of the worldwide-sample is performed to examine if "skimping" is also observed in this sub-sample[23]. Observed in table 4, for the sample the "skimping" hypothesis is clearly rejected. The coefficients of EFF on NPLs are not significant. However, unexpected the EFF1 normalized variable is both significant and positive related to NPLs, again, support for the "bad management" hypothesis. In addition, the control variable ROA also supports "bad management" with a negative sign. Furthermore, the controlling variable GDP is significant under 1% level and positive, meaning when GDP is rising, NPLs will increase. This finding is rather unusual, because normally when GDP is rising NPLs decline. The control variable RWA is significant at 1% level and positive, meaning when RWA is increasing, NPLs are also increasing for the EU banks. This finding suggest that a risky loan portfolio will eventually lead to higher levels of NPLs, consistent with Berger and DeYoung (1997). Important for the above-mentioned results is that the sample is relatively small, and the findings should be interpreted with caution. On the other side, the results show that for individual banks the effects could have a significant impact.

[22] Selecting the sub-sample for the most efficient banks this study took the median of the EFF ratio, which resulted in 30 observations. Therefore, the proxy EFF1 was taken to select the subsample. Thereby this study took all the complete observations per bank above the median. Furthermore, the subsample does not test for EU banks only, because the selected sample contains one EU commercial bank.

[23] Selecting the sub-sample for the most inefficient banks this study took the median of the EFF1 ratio, which resulted in 80 observations. Thereby this study took all the observations that were efficient in every year to avert banks who were efficient in some individual years. per bank above the median. Furthermore, the subsample tests for both the full- as for EU-sample.

4.2 Testing the bad luck hypothesis

In the EFF "bad luck" equation (3) the sign of the summed coefficients of NPL and NPL-EU is significant and negatively related to EFF. The finding is surprising since the sign is reversed of what is predicted, meaning the "bad luck" hypothesis is not supported. The latter indicates when NPLs increase, subsequently operating efficiency increases[24]. The literature has no explanation for this effect. A possible justification could be that when economies are growing e.g. interest rates rise, therefore the chance of default increases, subsequently because of the higher interest rates banks have greater, which increases the operating income. Second, the proxy EFF1, shows insignificant results for both the worldwide-sample and the EU-sample. Additionally, a robustness analyses is performed by checking an alternative model with non-stationary data for CAP and CAP-EU. The findings indicate significant positive results for the NPL-EU ($p<0.001$) on EFF, while it is insignificant for the worldwide-sample. Meaning commercial banks in the EU with higher levels of NPLs have lower operating efficiency.

4.3 Testing the moral hazard hypothesis

Berger and DeYoung (1997) tested the "moral hazard" hypothesis for a sub-sample, because they expected to see that thinly capitalized banks are willing to take more portfolio risk, which in the future leads to higher percentages of NPLs. Since there are not enough observations, a Granger-causality test is not possible. When selecting for a subsample of banks with capitalization below the median, only 28 observations are left. That is why this paper uses the entire sample to find support for the "moral hazard" hypothesis by estimating equation (2). This is not following the literature, but in this manner, we test for the effects. As observed in table 3, this paper finds no evidence for "moral hazard" in the both the worldwide-sample as the EU-sample[25].

As mentioned before, this study re-estimated equation (2) for two sub-samples; the most efficient banks and the most inefficient banks. Firstly, under the most efficient banks it is observed that CAP is negative related to NPLs and significant under the 1% level, confirming the "moral hazard" hypothesis. The result indicates that when capitalization decreases, the bad loan ratio will increase. Furthermore, the control variable GDP is positive and significant,

[24] This study performed a robustness analysis by excluding all insignificant dummies. Results indicate the main variables are insignificant from first model.

[25] A robustness analysis is performed, as described in the beginning of this section. The results are robust to include non-stationary data (not shown in table).

indicating when GDP levels grow, NPLs tend to increase which is in conjunction with previous findings described above. Secondly, for the sub-sample of the most inefficient banks, the summed coefficients of CAP are again statistically significant and negative related to NPLs supporting the "moral hazard" hypothesis. The finding implies inefficient commercial banks also tend to take more risk in their loan portfolios when capitalization decreases.

4.4 Testing the regulation hypothesis

Initially the CAP equation (4), is included to complete the model, as mentioned before. The summed coefficients for EFF and the normalized variable EFF1 are both positive, and insignificant which is unexpected, since a negative sign was predicted. However, the control variable ROA is positive and significant related (1% level) on CAP for both the worldwide-sample as the EU-sample. Indicating that bad performing banks Granger-cause reductions in capital buffers which is in line with the prediction. Hence, these findings support the hypotheses tested in the study, although cannot be directly related to one of them.

Secondly, "regulation" is rejected since the summed coefficients of NPL on CAP are negative and significant under the 10% level for the worldwide-sample. The results indicate when NPLs increase, CAP decreases, which is the opposite effect that is desired in relation with Basel regulation. However, the summed coefficients of NPL-EU on CAP are both positive and statistical significant under the 10% level. Suggesting if bad loans increase with 1%, the capital buffers also increase with 0.232168 for EU banks, which is in favour with the desired regulation Basel III and supporting the "regulation" hypothesis. A side note is that the results should be interpreted carefully because the p-value is rather big. In closing, for the EU-sample these results can be seen as positive, because the regulation from Basel is having the desired effect. Finally, controlling for RWA the summed coefficients are positive and significant under the 1% level, suggesting when RWA increases, capitalization buffers also increase and suggesting that higher risk lending strategies Granger-cause increasing capital ratios. Again, supported by Berger and DeYoung.

4.4.1 Comparing results

Comparing the results with those of earlier scholars, firstly, the positive significant effect of ROA on NPLs i.e. "bad management" for the worldwide-sample and EU-sample is consistent with Louzis et al. (2012) for Czech banks, Dimitrios et al. (2016) and Messai and Jouini (2013) for EU commercial banks. Hence, the performance indicator ROA may serve as a proxy for

management quality, because the results indicate that banks with decreasing performance, have higher ratios of NPLs. Additionally, evidence of "bad management" for the proxy of operating efficiency (EFF1) on NPLs for the worldwide-sample under the most efficient and inefficient commercial banks is in line with that of Berger and DeYoung (1997) for U.S. commercial banks, Louzis et al. (2012), Podpiera and Weill (2008) for Czech bank, and Williams (2004) for EU saving banks. Secondly, the conformation of the positive significant effect of ROA on NPLs i.e. "skimping" is consistent with that of Berger and DeYoung (1997) and Reddy (2011) for Indian commercial banks, implying these commercial banks freely trade loan quality for cost reductions on the short term, which leads to increasing NPLs on the long-term. However, the findings are inconsistent with Louzis et al. (2012) and Williams (2004) where they use the proxy loans loss provision as measure for NPLs. Thirdly, evidence of "moral hazard" of the negative effect of capitalization on NPLs for the most efficient and inefficient banks is in line with Berger and DeYoung (1997), Duran and Lozano-Vivas (2015) for the EU region, and Zhang et al. Zhang et al. (2016) for Chinese banks, which could be explained because these efficient commercial banks are increasing risk in their portfolios when capitalization decreases. Likewise, the findings of Nier and Baumann (2006) are consistent for worldwide banks, but suggest "moral hazard" exists because of government safety nets. Finally, evidence of "bad luck" of banks NPLs on operating efficiency for EU banks are persistent with that of Berger and DeYoung (1997), Podpiera and Weill (2008) and Rossi et al. (2005) for EU banks. It implies external events e.g. bankruptcy of companies causes these increasing NPLs because of defaulting loans and thereby operating costs increase because banks spend more on monitoring or working out arrangements for borrowers. In contrast, controlling for the relation of GDP on NPLs is insignificant which is inconsistent with that of Messai and Jouini (2013). Furthermore, they found that macroeconomic influences as unemployment rates are negative related to NPLs, and thereby effect efficiency which could also explain "bad luck", consistent with Makri et al. (2014) and Škarica (2014) for European banks.

Furthermore, the positive effect of ROA on capital buffers match those of Berger and DeYoung (1997). The conformation of "regulation" of banks NPLs on capital buffers for the EU-sample is in line with Rime (2001)) for Swiss banks. In contrast, Jacques and Nigro (1997) found that severally undercapitalized banks in the U.S. experienced relatively small increases, suggesting regulation did not have the desired effect.

Table 3

Granger-causality tests	Equation *(2)* worldwide and EU-sample		
Dependent variable NPL	Summed coefficients estimate	df	Prob.
			(N = 168)
EFF	-1.52E-05	3	0.8102
CAP	0.072402	3	0.8682
EFF1	0.027035	3	0.4703
ROA	-0.00035	3	0.9781
EFF-EU	-5.14E-05	3	0.9241
EFF1-EU	-0.076735	3	0.5038
ROA-EU	-0.005769	3	0.2368
CAP-EU	0.119824	3	0.6835
GDP	-4.85E-05	3	0.0533 ***
RWA	-0.005064	3	0.2964
	(Adjusted R2 = 0.958981)		
	Equation (3) worldwide and EU-sample		
Dependent variable EFF	Summed coefficients estimate	df	Prob.
			(N = 168)
NPL	-1,264.416	3	0.0135 **
CAP	-219.59841	3	0.8416
EFF1	0.027036	3	0.0008 *
ROA	-0.00035	3	0.0000 *
NPL-EU	-0.004845	3	0.0173 **
EFF-EU	3.47E-05	3	0.9553
EFF1-EU	-0.076735	3	0.0037 *
ROA-EU	0.076922	3	0.0001 *
CAP-EU	0.119824	3	0.9161
GDP	0.0001315	3	0.5509
RWA	-0.005064	3	0.4892
	(Adjusted R2 = 0.255871)		
Dependent variable EFF1			
NPL	0.023849	3	0.6491
CAP	-0.016548	3	0.7999
EFF	-1.34E-06	3	0.5893
ROA	0.000991	3	0.8674
NPL-EU	0.024141	3	0.8391
EFF-EU	-6.04E-05	3	0.4625
EFF1-EU	0.045886	3	0.8872
ROA-EU	-0.0003049	3	0.9905
CAP-EU	-0.029745	3	0.6977
GDP	2.26E-05	3	0.5899
RWA	0.003884	3	0.9620
	(Adjusted R2 = 0.890198)		

Table 3 (continued)

Dependent variable ROA			
NPL	2.663578	3	0.9839
CAP	-0.016216	3	0.9918
EFF	0.002769	3	0.0972 ***
NPL-EU	-3.433494	3	0.2320
EFF-EU	0.002098	3	0.0006 *
EFF1-EU	-11.595066	3	0.4253
CAP-EU	-0.483298	3	0.3632
GDP	-0.00643	3	0.1420
RWA	-0.015454	3	0.5169
	(Adjusted R2 = 0.794096)		
	Equation (4) worldwide and EU-sample		
Dependent variable CAP	Summed coefficients estimate	df	Prob.
			(N = 193)
NPL	-0.275282	3	0.0896 ***
EFF	8.30E-06	3	0.8799
EFF1	0.035256	3	0.1624
ROA	0.0062512	3	0.0000 *
NPL-EU	0.232168	3	0.0991 ***
EFF-EU	-3.18E-05	3	0.9506
EFF1-EU	-0.007418	3	0.8065
ROA-EU	0.007678	3	0.0092 *
CAP-EU	-0.095707	3	0.1684
GDP	4.77E-05	3	0.5860
RWA	0.037405	3	0.0004 *
	(Adjusted R2 =0.965676)		

Source: Bloomberg and own calculations.

Notes: ***, **, * Denote significance at the 1 percent, 5 percent, and 10 percent levels, respectively. Model is based upon three lags. Adjusted r^2 is relatively high for equation (2) and (4), meaning a high percentage of variation is explained by the independent variables. Thus, many data points fall within the line of the regression (Brooks, 2014). However, r^2 for equation (3) EFF is low, suggesting not all the variance is explained by the variables. For definitions of variables see table 2. To decide significance of variables, this study used the Wald-test, see Prob.

Table 4

Granger-causality tests	Equation (2) sub-sample most efficient banks		
Dependent variable NPL	Summed coefficients estimate	df	Prob.
			(N = 56)
EFF	0.000808	3	0.0000 *
CAP	-0.093272	3	0.0091 *
EFF1	-0.093953	3	0.5171
ROA	0.002606	3	0.0076 *
GDP	2.61E-05	3	0.0517 ***
RWA	0.008457	3	0.1170
	(Adjusted R2 = 0.986129)		
Granger-causality tests	Equation (2) sub-sample most inefficient banks		
Dependent variable NPL	Summed coefficients estimate	df	Prob.
			(N = 48)
EFF	-3.17E05	3	0.3098
CAP	-0.065653	3	0.0601 ***
EFF1	0.229154	3	0.0195 **
ROA	-0.009704	3	0.0004 *
GDP	0.000912	3	0.0000 *
RWA	0.068691	3	0.0001 *
	(Adjusted R2 = 0.9589810)		

Notes: ***, **, * Denote significance at the 1 percent, 5 percent, and 10 percent levels, respectively. All models are based upon three lags. Adjusted r^2 is relatively high for NPL, meaning most of the variation is explained by the independent variables. For definitions of variables see table 2. To decide significance of variables, this study used the Wald-test, see Prob.

5. CONCLUSION AND DISCUSSION

This study researched the relationship among NPLs, efficiency and capitalization thereby linking the effects of these variables to management quality and/or external events. With a panel dataset, the five hypotheses are tested using Granger-causality tests. Furthermore, this paper used a worldwide sample, and also tested with a sub-sample specifically for the EU commercial banks. The data provide evidence for an intertemporal relationship between loan quality and operating efficiency, since it runs in both directions. Overall, the "bad management" hypothesis is considered as leading for the entire dataset. Firstly, the "bad management" hypothesis is confirmed for the most efficient banks and inefficient banks worldwide – *meaning decreasing operating efficiency leads to higher levels of bad loans*. The findings indicate managers deliver subpar practices for e.g. credit rating and monitoring borrowers, which leads to excesses in expenditures and eventually banks are more prone to allow e.g. risky loans, consistent with that of Berger and DeYoung (1997), Dimitrios et al. (2016) and Louzis et al. (2012). Additionally, this study fund support for "bad management" for both the worldwide-sample and EU-sample – *suggesting that decreases in performance Granger-cause higher NPLs ratios.* The finding indicates that the performance indicator ROA may serve as a proxy for management quality and effect NPLs. The results match with that of Louzis et al. (2012), Dimitrios et al. (2016), and Messai and Jouini (2013). Secondly, the "bad luck" hypothesis is confirmed, proposing when NPLs increase, subsequently operating efficiency is declining. Apparently external events – *such as bankruptcy of firms lead to higher percentages of bad loans* – are only applicable for commercial banks in the EU, as there was no evidence found for the worldwide-sample. As a consequence, management tries to control the high percentages of NPLs with additional funds, such as extra resources for monitoring or/of selling loans which lower operating efficiency because these surplus resources lead to higher non-interest expenses. The results are consistent with Berger and DeYoung (1997), Podpiera and Weill (2008) and Rossi et al. (2005) for EU banks. To explain some of the external effects, this paper tested for GDP per capita, but found no significant results. Meaning there are other factors that could explain the effects, such as unemployment rates as Louzis et al. (2012), Messai and Jouini (2013), and Makri et al. (2014) and Škarica (2014) for European banks concluded.

Thirdly, the "skimping" hypothesis is confirmed for a subsample of the most efficient banks – *suggesting that increases in performance lead to higher NPLs ratios.* Which means the management of the banks deliberately save on short-term non-interest expenses e.g. monitoring costs with the consequence for long-term declines in loan quality, supported by Berger and

DeYoung (1997) and Reddy (2011) for Indian commercial banks. In contrast, the findings are inconsistent with Louzis et al. (2012) and Williams (2004) where they use the proxy loans loss provision as measure for NPLs.

Fourthly, both the most efficient as the inefficient sub-samples of banks show evidence for "moral hazard" – *banks with decreasing capital buffers are followed by increases of NPLs. Indicating managers have "moral hazard" incentives to allow more risky loans for higher returns because these banks have less to loose in case of default, since the risk is shifted to the creditors, which is backed by* Berger and DeYoung (1997), Duran and Lozano-Vivas (2015) for the EU region, and Zhang et al. Zhang et al. (2016) for Chinese banks. An explanation could be when banks default, most of the losses will be burdened by the creditors (Duran & Lozano-Vivas, 2015). An alternate explanation could be because of government guaranties in case of defaulting (Nier & Baumann, 2006).

Finally, this paper found evidence for the "regulation" hypothesis for the EU banks – *the result implies that when NPLs increase the capital buffers increase*. Meaning the actions and regulations of Basel III is having the desired effect. Consistent with these finding, Rime (2001) found Swiss banks react similar to regulation from governments. In contrast, Jacques and Nigro (1997) found that severally undercapitalized banks in the U.S. experienced relatively small increases, suggesting regulation did not have the desired effect. Overall, the finding suggest that Basel III regulation is decreasing the risk banks expose in financial shocks e.g. financial crisis. Important for the above-mentioned results is that the findings should be interpreted with caution since the economic effects are rather small. On the other side, the results show that for individual banks the effects could have a significant impact regarding the five hypotheses.

5.1 Practical implications

The findings of this study have several contributions in the understanding of NPLs in relation with operating efficiency and capitalization for commercial banks both worldwide as in the EU. The intertemporal relation between operating efficiency and NPLs contributes first of all to the understanding of management behaviour in banking, since the financial instability of banks – during and after the crisis of 2008 – is possibly affected by management choices i.e. "bad management". In this case, efficiency is an important catalyser for rising NPLs. Therefore, policy implications for e.g., Basel regulators could be to emphasize more on efficiency measures by examining multiple financial ratios to prevent future financial instability of banks

and even default. Secondly, the "bad luck" hypothesis propose that NPLs increase due to external events, could lead to low measured efficiency as we have seen during the financial crisis. Besides, several scholars have shown that high levels of NPLs could cause bank failure and insolvency (Barr et al., 1994; Berger & Humphrey, 1991; DeYoung & Whalen, 1994; Wheelock & Wilson, 1995). To advert these risks, policies makers could limit the effects of external events – such as shocks from e.g., increasing employment rates – by restricting banks on *total loan to asset ratios* levels, thus banks cannot have enormous percentages of bad loans. In addition, more tighter capital requirements could prevent insolvency. In this case the policy implication could be to extend Basel regulation even more in the future.

Thirdly, the "skimping" hypothesis shows that internal sources of risk can influence the loan quality of banks, because banks are in a trade-off between short- and long-run strategies. Regulators could in this case monitor for instance internal procedures for e.g. loan allowances to advert future volatility.

Finally, for the "regulation" hypothesis the practical implications are obvious since the hypothesis is confirmed for the EU banks, meaning that the regulation of Basel III is having the anticipated effect. However, for the full sample Basel III seems to fail, since this study shows evidence for increasing risk in the loan portfolios is followed by decreasing capital buffers. For regulators and policy makers these signals should be alarming, since the regulation is applicable for the worldwide sample. Therefore, it is advisable to keep monitoring the applied rules and regulation for the long run, and if necessary intensify Basel regulation as mentioned above.

5.2 Limitations and future research

Despite this study found significant outcomes, there are some limitations which are important when interpreting the main findings. The study tried to explain the effects of NPLs, operating efficiency and capitalization in the banking sector. As follows, the construct "bad luck" explains less than 25% of the variance. Extending the model with more explanatory variables – e.g. interest rates, unemployment rates, and inflation rates – to explain the external effects of increasing NPLs might contribute to a more complete research model.

In the second place, the findings show that both performance indicators and efficiency measures influence NPLs, however results could be more precise if a more comprehensive method for efficiency measures was used. This paper used a relatively common used efficiency measure, whereas for instance Berger and DeYoung (1997) and Williams (2004) used a cost frontier which covers more in- and output variables. Subsequently, the current study could miss

significant information for certain variables who can explain the researched constructs. This study tried to restrict effect by using multiple measurement for efficiency namely; 1) operating efficiency, 2) normalized operating efficiency, and 3) ROA as control variable.

In the third place, the sample size is relatively small in comparison with other studies. See for instance, Williams (2004), Berger and DeYoung (1997) and Tabak et al. (2011). One of the reasons mentioned before, is that the access to the data was difficult and had to be manually collected. Generally, by expanding the sample size, the external validity and generalization are more powerful over the population. However, other scholars have shown significant results with comparable studies (Louzis et al., 2012; Podpiera & Weill, 2008). Despite the relatively small sample size, this study selected the thirty largest worldwide banks in total assets.

Finally, the sample is subject to sample bias, as the total assets ratio was a hard criterion to include or exclude certain banks. When adding smaller banks, the results could be more homogenous for the worldwide sample. However, the problem with smaller banks is that the data for NPLs is not always available as this study has experienced.

Furthermore, the study provides several recommendations regarding future research, as suggested below. It is recommended to further investigate the negative relation between NPLs and operating efficiency by expanding the dataset, since the finding is rather unusual. The outcomes can be disruptive if multiple future scholars support the finding, because it provides a whole new explanation between rising bad loans and increasing efficiency in the banking sector. More specifically, the focus should be to explain the effect, which might be found in economic growth and increasing interest rates. More specific, economic growth could increase the level of bad loans because of higher interest rates, but at the same time the income of banks will increase because other debtors are still transferring the obligation owed. Finally, the "regulation" hypothesis shreds some new insights on the regulation of Basel III. The regulation of Basel should prevent future instability of financial markets, for this reason it is even more essential – in relation with social interest – to find homogenous results by including more worldwide samples.

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APPENDIX A – F-values

Equation	*Number of lags included*	*1*	*2*	*3*	*4*	*5*
(2)	F test value	386.84	281.673	279.9837	174.3805	130.3998
	R-Square	0.940439	0.961138	0.976694	0.977234	0.981662
	Adjusted R	0.938008	0.957726	0.973205	0.97163	0.974134
(3)	F test value	1.452849	2.103668	2.863792	2.515924	2.671234
	R-Square	0.05598	0.155913	0.299678	0.382451	0.52304
	Adjusted R	0.017449	0.081798	0.195464	0.230439	0.327235
(4)	F test value	503.3434	646.3208	579.3125	264.5778	392.1286
	R-Square	0.934434	0.982684	0.988656	0.991842	0.993826
	Adjusted R	0.912434	0.981164	0.986967	0.989834	0.991292

APPENDIX B – ADF-Fischer test

Variable	*ADF-Fischer*	*Prob.*	*ADF first difference*	*Prob.*
NPL	129.401	0.0000		
EFF	194.334	0.0000		
EFF1	122.781	0.0000		
CAP	63.3647	0.3586	265.113	0.0000
ROA	134.311	0.0000		
GDP	78.2807	0.0566		
RWA	81.6287	0.033		
NPL-EU	60.2015	0.0009		
EFF-EU	88.3218	0.0000		
EFF1-EU	64.051	0.0000		
ROA-EU	83.8651	0.0000		
CAP-EU	23.0519	0.8131	131.0810	0.0000

APPENDIX C – Correlation matrix

	NPL	*EFF*	*CAP*	*EFF1*	*ROA*	*NPL-EU*	*EFF-EU*	*EFF1-EU*	*ROA-EU*	*CAP-EU*	*GDP*	*RWA*
NPL	1.000											
EFF	-0.076	1.000										
	(0.86)											
CAP	-0.146	-0.153	1.000									
	(0.00)	(0.00)										
EFF1	0.040	-0.172	0.395	1.000								
	(0.56)	(0.00)	(0.00)									
ROA	-0.422	0.013	0.427	0.001	1.000							
	(0.00)	(0.81)	(0.00)	(0.01)								
NPL-EU	0.893	0.026	-0.240	0.005	-0.473	1.000						
	(0.00)	(0.60)	(0.00)	(0.47)	(0.00)							
EFF-EU	0.000	0.594	-0.098	-0.111	-0.048	0.036	1.000					
	(0.96)	(0.00)	(0.11)	(0.05)	(0.44)	(0.59)						
EFF1-EU	0.384	0.020	0.388	0.358	-0.436	0.088	0.023	1.000				
	(0.00)	(0.67)	(0.00)	(0.00)	(0.00)	(0.00)	(0.80)					
ROA-EU	-0.101	0.046	-0.043	0.066	0.381	-0.011	0.074	0.297	1.000			
	(0.00)	(0.74)	(0.69)	(0.94)	(0.00)	(0.00)	(0.59)	(0.68)				
CAP-EU	0.511	0.065	-0.261	0.170	-0.408	0.277	0.099	0.06	0.368	1.000		
	(0.00)	(0.24)	(0.00)	(0.00)	(000)	(0.00)	(0.13)	(0.00)	(0.28)			
GDP	-0.063	-0.007	-0.097	0.402	-0.475	0.036	0.029	0.367	0.051	0.262	1.000	
	(0.27)	(0.96)	(0.11)	(0.00)	(0.80)	(0.59)	(0.64)	(0.03)	(0.98)	(0.00)		
RWA	-0.086	-0.099	0.739	0.280	0.582	-0.247	-0.116	-0.449	-0.042	-0.378	-0.436	1.000
	(0.12)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.04)	(0.00)	(0.83)	(0.00)	(0.00)	

Notes: (.) Denote significance for correlations. The high correlation between CAP and RWA is possibly explained because regulators demand that banks with certain portfolio strategies need to have higher capital buffers (Berger & DeYoung, 1997).

APPENDIX D – Bank sample

Bank name
Agri culture bank of China
Banco Santander
Bank of America
Bank of China
Bank of Communications
Barclays PLC
BBVA
BNP Paribas
China Construction bank
Citigroup Inc
Commercial bank of China
Credit Agricole Group
Credit Suisse Group
Deutsche Bank
Groupe BPCE
HSBC Holding
ING Groep
Japan post bank
JPMorgan Chase and Co
Lloyds bank
Mihuzo Financial Group
Mitsubishi UFJ
Norin Chuckin bank
Royal bank of Canada
Societe Generale
Sumitomo Mitsui
UBS AG
UniCredit S.p.A
Wells Fargo
(Total =30)