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THE IMPACT OF CAPITAL REGULATION ON BANKS' COST AND PROFIT EFFICIENCY UNDER STRESSFUL ECONOMIC CONDITIONS: CROSS-COUNTRY EVIDENCE

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Abstract

This thesis evaluates how regulation on capital requirements is associated with cost and profit efficiency of banks. It allows an international comparison on banking regulation, capturing changes on public policies towards banks over time further, it encompasses one of the major financial crises since 1929. The impact of regulatory capital requirements on banking efficiency is assessed using the stochastic frontier production function for panel data to estimate inefficiency effects. It is used a panel dataset of 865 observations from 156 publicly listed commercial banks operating in 30 countries and covering a nine year time-horizon (2004-2012). Besides the impact on capital regulation, we also controlled for the influence of other regulatory variables, macroeconomic conditions, market structure characteristics and the state of financial development. Our results suggest that capital requirements negatively affect inefficiency, meaning that, for our sample, an increase on regulatory equity ratios will lead to an efficiency improvement. Regarding other regulatory control variables, we would say that regulation should aim to increase market discipline, while restricting banks activities. The power of supervisory agencies seems to negatively impact banks' efficiency, but in in stressful conditions, it may help banks being more cost efficient.

JEL classification: G21, G28, D24, C23, C24

Keywords: Banking, Regulation on capital requirements, Cost efficiency, Profit efficiency, Financial crisis, Stochastic frontier analysis.

Contents

List of Tables

List of Figures

List of Acronyms

BIS – Bank of International Settlements

BRSS – Bank Regulation and Supervision Survey

FDIC – Federal Deposit Insurance Commission

FDICIA – Federal Deposit Insurance Improvement Act

GDP – Gross Domestic Product

IMF – International Monetary Fund

OCC – Office of the Comptroller of the Currency

USA – United States of America

USD – United States Dollars

Chapter 1 | Introduction

The banking sector has an on-going track record of instability and systemic crisis which impacts either locally – e.g. Sweden 1990's banking crisis – or globally – e.g. United States sub-prime financial disaster in 2007-2008. But financial crisis are not a product of the last decades. In a brief history of the financial crises, The Economist (2014a) lists relevant ones, being the first reference to an episode in 1792 in the United States of America. As financial crisis occur, one after another, leaving legacies of bankruptcy, unemployment and poverty, institutions and regulatory standards have been designed to increase the system resilience and minimize its natural tendency to instability. Such measures encompass, among others, the establishment of deposit insurance schemes, the definition of minimum capital requirements, and the design of regulatory and supervision authorities. Nevertheless, financial development made the financial system more interconnected (Rajan, 2005). Hence, as the 2007-2008 financial turmoil has shown, the regulatory framework in place has not proved to be efficient in preventing the causes of this major shock. All over the world, many financial institutions have been bailed out by national governments, at taxpayers' expense, in what was understood as the major financial crisis after the world's biggest in 1929 (The Economist, 2014a). Just after the implementation of a set of rules known as Basel II, the debate on how to improve regulation to minimize the risk of a new episode in the near term was again open.

The debate arises because either among the industry or the academia, it is understood that regulation on the banking sector affects banks' performance. Due to the important role of banks in providing financial services to the rest of the economy, the impact of regulation has been a matter of study, namely at the international level. Barth, Caprio and Levine (2004) conducted a study on the relationship between banking supervisory and regulatory practices and banking sector development and fragility. This study is particularly relevant because it used a database on bank regulation in 107 different countries. The authors did not find a close link between capital regulation and bank performance. More recently, Beltratti and Stulz (2009) have studied the relationship between capital supervision and banks' performance during the month following Lehman Brothers bankruptcy. Capital or equity plays an important role on banks because it acts as a loss-absorber, preventing financial distress and potential insolvency

(Admati et al., 2010). Among many dimensions of the regulatory framework which are applied to the banking sector, regulation on capital requirements is probably the most discussed. A new regulatory framework – known as Basel III – aims to raise the quality, consistency and transparency of capital base. Among the industry, any new regulation that forces banks to raise more capital is generally unwelcome. Usually the debate on capital requirements imposed on banks is based on their impact on profitability, with hypothetical trade-offs between banks safety and banks being an attractive investment (The Economist, 2013a). However, from a public policy perspective, regulation on capital requirements should be evaluated on its impact on banking efficiency and not on a profitability framework only. Therefore, this dissertation aims to address the impact of capital regulation on banks' efficiency in a context of financial distress. Such context is not negligible because it is usually in adverse scenarios that it is realized that the regulatory framework in place is not enough in helping to stabilize an inherently unstable system.

Prior studies have addressed bank efficiency. Dietsch and Lozano-Vivas (2000) studied the impact of environmental conditions on banks' cost efficiency using a sample of French and Spanish banks. However, due to data limitations, the study has used proxies as industry average capital to capture the impact of capital regulation. Gregorian and Manole (2002) address bank efficiency on transition countries of Eastern Europe and former Soviet Union. The authors also try to understand how capital regulations impacted banks performance. In 2005, Fries and Taci used the European Bank for Reconstruction and Development index of banking sector reform to access the impact of institutional developments on banks' cost efficiency for 15 post-communist countries. More recently, Pasiouras, Tanna and Zopounidis (2009) conducted an international comparison of the three pillars of Basel II on banks' cost and profit efficiency. Regulatory variables on capital requirements were defined using data from the Bank Regulation and Supervision Survey conducted by the World Bank.

This thesis has some common aspects with the aforementioned studies, especially with Pasiouras, Tanna and Zopounidis (2009), as it aims to analyze how capital regulation impacts on bank efficiency while controlling for other regulatory and environmental variables. It covers both cost and profit efficiency measures because analyzing only a single dimension of banking efficiency can be deceptive, as sustained by Guevara and Maudos (2002). And give us also an international comparison on how different

regulatory, economic, and environmental conditions may turn capital requirements more or less relevant in the way banks operate. But the main advantage of our study is to use a panel data over the period 2004-2012. This is particularly relevant for three reasons: first, while using panel datasets we are expected to obtain more efficient estimators of the unknown parameters and more efficient predictors of efficiency estimates (Coelli et al., 2005); second, we use a longer time-period than Pasiouras, Tanna and Zopounidis (2009), which allow us to capture not only environmental and economic changes over time, but also regulatory updates, since we were able to use data from two Bank Regulation and Supervision Survey conducted by the World Bank (2007 and 2011); finally, we capture a period that probably encompasses the biggest financial crisis since 1929. If we want to capture the effect of capital regulation on banking efficiency, which is usually designed to define minimum buffers to help banks overcome unexpected losses, it will be very useful to analyze how regulation may (or may not) help banks' efficiency in such a stressful economic context. Beltratti and Stulz (2009) found that "banks that had higher Tier I capital ratio in 2006 and more deposits generally performed better during the crisis". Instead of using traditional measures of performance (e.g. return on equity), our approach will apply efficiency measures which, according to Berger and Humphrey (1997), are "particularly valuable in assessing and informing government policy regarding financial institutions".

The remaining chapters of the thesis are structured as follows: Chapter 2 provides an overview on the literature on capital, on banks' capital structure major trends and on capital regulation; Chapter 3 presents the methodology and how our dataset was built; Chapter 4 discusses the results obtained; and Chapter 5 presents the main conclusions.

Chapter 2 | Related literature and theoretical focus

2.1. Why is capital important?

When a company wishes to start an activity, whatever the role and objectives the organization may want to accomplish, the firm needs to choose how it will be financed. Although there are currently financing approaches which may include several instruments with mixed properties, to better understand the role of capital let us assume that the firm can only choose between debt – e.g. bonds – and equity (we will refer to equity or capital interchangeably). According to Modigliani and Miller (1958), in a world without taxes or any other market imperfections, this decision, i.e. the company capital structure, should not have any kind of impact on the value of the firm, so it would be indifferent the way companies finance their activities. But does this conclusion mean that capital would not have any kind of importance? In the real world there are taxes and all sort of market imperfections and we realize that firms have different capital structures, so using different mixes of debt and capital will certain play its role among management decision making processes. Damodaran (2001) states that firms' capital structure should be analyzed on a framework where debt has two advantages relative to equity – tax benefits and management discipline. The tax benefits come from having a differentiated treatment of costs associated with the debt, namely the deduction of interest payments in the calculation of earnings before taxes. Management discipline which arises with debt is typically associated with two stylized facts: the debt requires mandatory periodic payments (e.g. paying a coupon of a bond); and as debt has fixed maturities, it needs to be periodically refinanced which may not be achieved at the same cost or not possible at all if it is perceived that management is not conducting the firm as efficiently as they could.

Besides these two advantages, the higher the debt ratio in the financing mix, the higher the profitability for the equity stake in the good times. Consider the following example: you wish to purchase an asset which returns 105 for each 100 invested in good times. If this asset is financed completely with equity, the return for the investor will be equal to the return on asset, i.e., 5%. Alternatively, imagine you ask for a loan of 80, for which you will have to pay 3 (plus the 80 borrowed). With this second financing approach, the remaining 22 (105-83) will be left for the equity holder, which doubles the return on equity that may be obtained from the same asset with a 100% equity capital structure.

So, if we sum up the two advantages described early with the leverage effect described latter, one might think that any operation should be financed with as much debt as possible. However, these advantages should be weighed against three costs: bankruptcy costs, agency costs, and loss of future financing flexibility (Damodaran, 2001). Bankruptcy costs arise before bankruptcy indeed happens and can be somehow defined as the additional costs a company faces when somehow it is perceived that something is wrong with the firm. Companies' suppliers may stop conceding any kind of credit, customers may reduce the demand for goods or services from a company which may fail in the future, and employees may start looking for jobs in other companies. In turn, agency costs may arise from the conflict of interests between debt holders and equity holders. At high leveraged firms, those conflicts may turn into debt overhang problems, which affect not only the company investment decisions – equity holders do not have incentive to finance new projects in a highly leverage firm because projects' value added will be largely taken by debt holders – but also any decisions regarding deleverage – "even when this would increase the combined value of the firm to shareholders and creditors" (Admati et al., 2012). Since not always the actions conducted by the management serve equity holders and bond holders, the latter may impose additional costs to the firm through covenants or restrictions on assets where funds can be applied. Finally, the third cost derives from the loss of future financing flexibility which arises when an indebted company loses the capacity to borrow new funds to finance new projects.

So, capital plays an important role in the way firms finance their assets. But let us go back to our previous investment example. We said that the asset would return 105 in good times. But what would happen if the return in bad times were only 101? On the capital structure with 100% equity, the return would be 1%. However, with the second capital structure, after paying for the costs of debt, nothing would be left for the equity holders (more precisely, equity holders will get a loss of 2, or 10%). So capital has played the important role of absorbing losses when bad times arrive. This simple example is consistent with what truly happen in companies. Ross, Westerfield and Jaffe (2004) highlight that empirically, on average, most of non-financial corporations have low debt-assets ratios – a number of firms use no debt at all which sustains the important role of capital. An additional feature regarding capital structure which may also be found empirically is that it seems there are differences in the capital structures of

different industries: Drugs and Electronic firms have low leverage whereas Hotels and Lodging and Building Constructing companies have higher debt as a percentage of the market value of equity and debt. So, capital structure and the role of equity is one of the most debated issues in corporate finance and different theories try to address this particular issue – as firm's life cycle, following a financing hierarchy, or matching industry average capital ratio.

Even though financial institutions are among the most leveraged firms (Berger, Herring and Szegö, 1995, Admati et al., 2010), they are somehow set aside when it comes to capital structure analysis in corporate finance. This is usually justified by the specificity of their activities and by the fact that their capital structure decisions are often influenced by regulation. The aforementioned empirical studies quoted from Ross, Westerfield and Jaffe (2004) explicitly excluded financial firms. But are financial firms, particularly those who operate in the banking sector, a special case when it comes how to choose the best financing mix? Are the advantages and drawbacks associated to the use of equity and debt and described early not applied to banks? Ross, Westerfield and Jaffe (2004) highlight that although there is no formula to define the optimal capital structure for a particular company, three important variables should be considered when choosing the financing mix: taxes, types of assets, and uncertainty of operating income. The role played by taxes was already addressed, so we will not discuss this topic any further. Types of assets may impact the firms' capital structure in the sense that if a company holds illiquid assets, it may not be able to sell them to deal with a situation of financial distress. Therefore, ceteris paribus, it is expected that firms with illiquid assets – as investment in research and development – hold more capital than firms with liquid assets. The uncertainty of operating income may lead to choose less leverage in the firm's capital structure. Otherwise, debt may cause additional pressure on companies' volatile cash-flows (remember the example above, where equity played its role as loss absorber).

Damodaran (2001) added three additional variables to the preceding list: the need for flexibility, the separation of ownership and management, and debt holders' difficulty in monitoring firm actions, investments, and performance. Holding all other remaining variables fixed, if a company foresees the need of decision-making flexibility in the future, it is expected that it starts to deleverage. In what concerns to the separation of ownership and management, more debt is usually associated to a great separation.

Finally, when it comes to the difficulty of debt holders to monitor the firm's activities, the greater the opacity on the company actions, the lower is expected the firm's leverage to be. So, let us exclude taxes because it depends the way tax codes treat the costs associated with debt, and not least, it also depends on the firm's capacity to generate earnings in the first place. All other five remaining variables described before seem to be a consequence of the "nature of equity claims on the firm's cash-flows" (Damodaran, 2001). "Equity claims entitle the holder to any cash-flow left over after meeting all other promised claims" (Damodaran, 2001), and, again, that is why capital or equity plays an important role on companies: because it acts as a loss-absorber, it is a tool of preventing financial distress (Berger, Herring and Szegö, 1995).

Hereupon, we have understood the role of equity as a loss absorber and why it is important on companies' capital structure in general. But is there any particularity of the banking sector that might be specific that the aforementioned framework on capital structure – and the role of capital on it –could not be applied to banks as well? Besides everything that has already been said about the role of capital, when it comes to the financial industry, it is also important to address two additional features of the banking sector that should raise additional red flags on how banks choose their capital structure. Banks provide various services to all remaining sectors of the economy. Therefore, a bank failure could thus be very costly either to providers or to users of savings (Saunders and Cornett, 2011). On one side, a bank failure may destroy households' savings. But a bank failure may also freeze all lending activities leaving firms and households without access to credit. Examples of this negative externalities are, unfortunately, quite frequent. Even a small doubt about the resilience of a bank may drive the entire system into real solvency problems and drag the entire economy with them. So a problem with a bank may impact negatively the economic prospects of the remaining stakeholders. The second feature is the interdependence. As Rajan (2005) recognizes, financial development has turned the system more interconnected "with a more pronounced linkage between markets, and between markets and institutions". Admati et al. (2010) support that interconnection magnifies any insolvency problem, spreading consequences all over the entire economy. Consequences that are clearly translated in prolonged and deeper recessions experienced not only in the past but also more recently, as we witnessed after the Lehman Brothers collapse. Similar claims have also been supported by Adrian and Brunnermeier (2011).

Therefore, the capital structure of the financial system, by its particularities and idiosyncrasies, should be managed carefully because a problem in one institution can jeopardize not only other banks but also households, and companies operating in the real economy. As mentioned before, "equity is considered a "cushion" or a "buffer" because its holders do not have a hard claim against the issuer" (Admati et al., 2010). For the banking sector this idea is even more crucial, given its externalities on the economy. In such a crucial way, it became a matter for regulation. But we will address the regulation topic later on. We were saying that banks capital structure is a crucial matter. However, even though the role of capital might seem as clear as it is essential, "one of the most remarkable features of the financial crisis of 2008 was the razor-thin capitalization of many of the world's largest banks" (The Economist, 2014b). Hellwig (2010) supports the same claim as well, establishing a connection between fragility and interconnections among financial institutions, even though Berger et al. (2008) suggested that large banks in the United States were holding capital in excess of the minimum required by regulators.

Despite of its importance to the soundness of each financial institution and, by extension, the entire financial system, setting the right equilibrium between equity's role and how much leverage should a bank have generates a lot of controversy in the industry and also among regulators. Let us consider, for instance, a bank with capital less than 5% of its total assets: this means that for every 100 the bank has invested, it will go bankrupt if losses are equal or greater than 5. And in years preceding the 2008 crisis, equity levels were at historic low with leverage ratios around 50 (The Economist, 2013). It is possible to look at the capital structure of an institution as its leverage ratio or collateral rate of the institution (Geanakoplos, 2010); hence, in the previous example, leverage around 50 would mean that banks were financing their operations with capital around 2%. So, capital is important for banks – remember that with those capital ratios, banks could not absorb losses greater than 2 – because "when banks are highly leveraged, even a small decrease in asset value can lead to distress and potential insolvency" (Admati et al., 2010). Further, when firms have a great presence of equity in their financing mix, typically are "less inclined to make excessively risky investments that benefit shareholders and managers at the expense of debt holders and government", and because even "when insolvency is not an immediate problem, following a small decrease in asset values, highly-leveraged banks may be compelled to sell substantial

amount of assets in order to reduce their leverage, putting pressure on asset markets and prices, and thereby, indirectly on other banks" (Admati et al., 2010). So, the equity level of each institution may not be a panacea, but it is definitely important, especially for banks. It is important for the soundness of the bank itself, which acting on its own interest should consider an equity level which allows it to continue to operate even in the rainy days. And banks face many incentives to choose not to do so. Bonfim and Kim (2012) have analyzed the risk taking behavior of a given bank when other banks are following riskier strategies, concluding that in such scenario, there are evidences of "herding behavior among the largest banks". This occurs specially if banks believe that "they will be helped out if they face severe difficulties, thus having perverse incentives to engage in excessive risk-taking behaviors" (Bonfim and Kim, 2012). Therefore, equity levels are also a matter of concern when managing systemic risk. So, regulation should not care only about each particular bank operating in the market, but with the risk of the entire system, guaranteeing that banks do have capacity to withstand shocks because "as the financial crisis of 2007-2008 has compellingly shown, highly leverage financial institutions create negative externalities" (Admati et al., 2010) for the entire economy. Now that we have a better view on why capital is important, and its crucial role on the soundness of banks – and, as consequence, in turning the financial system safer –, let us turn our attention to the evolution of capital structure in the banking sector and what kind of events might cause it to change.

2.2. Capital structure in banking: global trend and historical evolution

Previously, while discussing the role of capital in the financing mix of a firm, we have identified a set of variables that may influence the optimal capital structure. Those variables included tax codes, type of assets the company holds on its balance sheet, uncertainty of firms' operating income, flexibility to select which projects the company should invest in, the separation of ownership and management, and debt holders' difficulty in monitoring firm actions, investments, and performance. For each one of them, companies should weigh the costs and benefits associated with distinct capital structures. For non-financial corporations, it is expected that in the decision making process both debt-holders and equity holders internalize the costs and benefits of such variables, so those are not a matter of public concern (Herring, 2011). Therefore, the evolution of a specific industry capital structure, if any, may, somehow, be explained by

changes in the aforementioned variables and consequently, by the relative costs and benefits associated to each one of them.

However, when it comes to banks' capital structure, the observable changes over time may be explained by something else. Or at least, it is possible to establish some correlation between public policy events that helped to create and develop the safety net to the banking industry and the continuous increase in leverage within the industry. But let us look at the evolution of banks' capital structure over the last 150 years using data from United States banks' capital structure since 1834 (Berger, Herring and Szegö, 1995; Herring, 2011) – a similar pattern has been identified in banks from the United Kingdom and Germany (Admati et al., 2010), so let us assume that it is quite representative of the main trends in the industry. The graph with the United States banks' capital ratio trend for the period 1834-2010 can be found in Figure 1.

Figure 1 - The evolution of leverage in United States banks (1834-2010) (Herring, 2011)
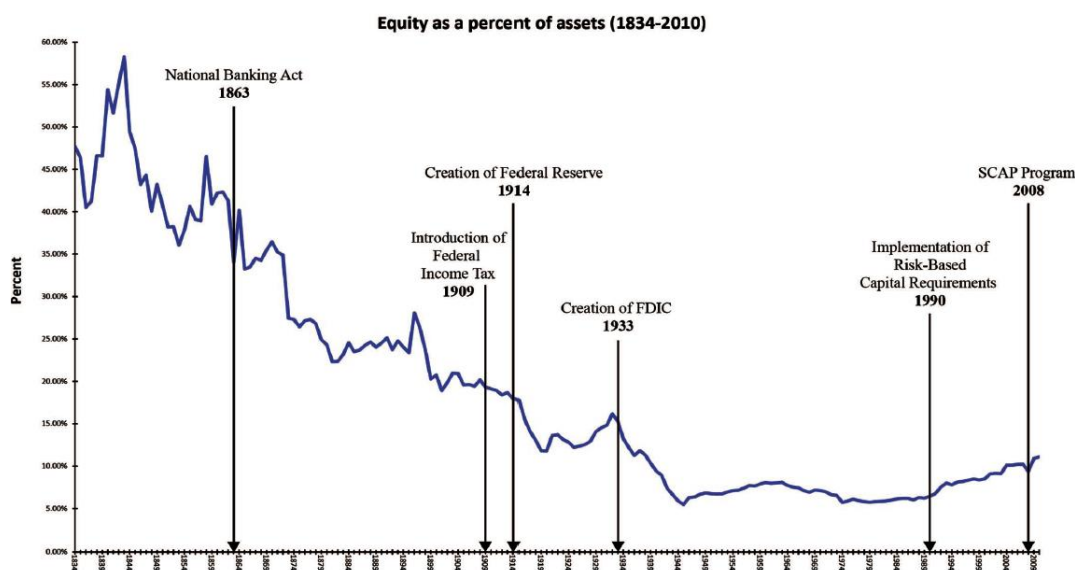
Looking back to 1834, the first conclusion is that banks' equity to total assets ratio has been quite higher in the past when compared to nowadays levels or the regulatory proposals under discussion – minimum total capital of 8% (BIS, 2010a). Starting from equity to total assets ratios of 50%, leverage has followed a clear growing trend until 1940's. From the 1940's onwards, equity to total assets ratio has been within a lower limit of 6% and an upper limit of 8%. So, what may have contributed to the clear descending trend from almost 50% of equity to total assets to only 6% – a decrease of almost 90% – on banks' capital structure in the period 1834-1944? Can the increase in

leverage be explained by particular changes on variables identified by corporate finance theories?

According to Berger, Herring and Szegö (1995), this decrease may have started by improvements in the financial system. These enhancements included geographic diversification, the introduction of money markets, clearinghouses, and mutual guarantees associations – allowing banks to access liquidity beyond their own markets. This analysis is also supported by Herring (2011), which highlighted the role of technology improvements at the time such as the telegraph and national railway connections. These set of improvements may have contributed to the decline of the probability of financial distress, which, as we saw earlier, can be mitigated also with higher capital ratios. Therefore, improvements in the financial system and in technology may have been understood as an indicator that less capital was needed and may help to explain the initial declining trend in banks' equity ratios.

However, due the externalities for the economy of successive financial crisis, public policy started to be aware of "the social costs to the general public from banking crises" (Haldane, 2010) and introduced regulation with the objective of reducing the probability of such happenings. And not only regulation itself, but also the way public policies have been answering to each slump, with discretionary bailout decisions, may also influence how banks have been choosing their capital structure over time (The Economist, 2014a).

Let us again return to the historical data on United States bank's capital structure to analyze if such claims found support in the observable trend (Figure 1). Following the National Banking Act in1863, which introduced the Office of the Comptroller of the Currency (OCC), the increasing trend on banks leverage has accelerated – because banks trusted the role of OCC in monitoring national banks – stabilizing capital to assets ratio around 25% in 1880's, i.e., a drop of 50% from 1834 starting point. Again, it was another slump caused by the financial system – Knickerbocker crisis (The Economist, 2014a) –, that led to the establishment, in United States, of the Federal Reserve System in 1913, which should start acting as a lender of last resort. Following this improvement of the safety net on the banking system – banks started having a discount window where they could have access to liquidity – derived form public policy aim to stabilize the banking system, it was observable an immediate drop on banks'

capital to total assets ratio. Besides the contribution of the Federal Reserve System, Herring (2011) highlights that the increase in corporate tax that followed the beginning of World War I (1914-1918) may also have contributed to increase banks' leverage, which is indeed aligned with corporate finance theory on optimal capital structure. The declining trend in banks' capital ratio is somehow interrupted during the years of the great depression – not surprisingly, another financial crisis – in the 1920's. However, "the response to a financial crisis has always followed a familiar pattern, ending by entrenching public backing for private markets: other parts of finance deemed essential are given more state support" (The Economist, 2014a). Thus, the great depression led to another major change in regulation that strengthened even more the safety net designed for the financial system and restored the preceding declining trend in banks' equity to total assets ratio. In the early 1930's it was established the Federal Deposit Insurance Commission (FDIC) with the objective to protect depositors of bank failures and avoid bank runs (Berger, Herring and Szegö, 1995; Herring, 2011). Berger, Herring and Szegö (1995) sustain that the creation of FDIC "provided an additional subsidy to banking that also made uninsured bank debt safer, reducing market capital requirements further". Similar idea is defended by Geanakoplos (2010). Depositors no longer need to monitor which bank was safer, since no matter how banks manage their risks, there will always be a public fence protecting depositors' savings. Again, as sustained by the data on United States banks' capital structure, this major regulatory change was followed by an acceleration of the declining trend in banks' equity to total assets ratio, dropping from circa 14% to around 6% in 10 years which is a reduction of more than 50%. This drop lasted until 1940's, when capital to total assets stabilized and started fluctuating on a 6%-8% collar (Figure 2). It remained in this band for almost half century (Berger et al., 1995), which may be understood as a signal of its success in preventing the main cause that led to it: bank runs. On the other hand, as regulation improved the safety net around the financial system, it also created "perverse incentives to engage in excessive risk-taking behaviors" (Bonfim and Kim, 2012) to the extent that allowed banks "to reduce costly liquidity and equity buffers" (The Economist, 2014a).
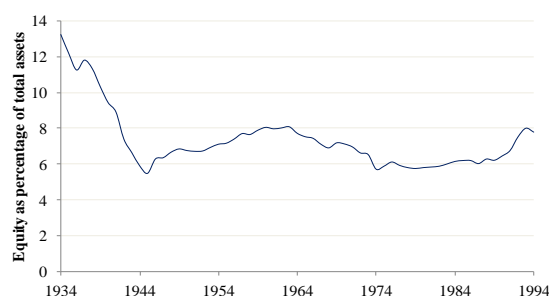
In the 1990's, after a long period where capital ratios remained quite stable, the Federal Deposit Insurance Improvement Act (FDICIA) forced banks to start slightly decreasing leverage (Herring, 2011) because it imposed limits on leverage based on total assets (Berger, Herring and Szegö, 1995). According to Herring (2011), this change in banks' leverage was only observable in banks which were under United States jurisdiction. Banks that needed to comply only with Basel Capital Accord continued with their capital to total assets ratio around 6%-8% or even lower. Herring (2011) explained that this was due to the arbitrage made on regulation, namely the equity to risk-weighted assets ratio which could be easily manipulated. The same argument can also be found in Admati et al. (2010) and Hellwig (2010). Cebonyan and Strahan (2004) add that the Basel Capital Accord may have contributed to increase leverage rather than reducing risk in the banking system as banks were able to define the risk associated to their assets. Indeed, financial institutions were reporting 10% core capital, when these figures relate equity to risk-weighted assets (Hellwig, 2010). "If the risk weights have not been chosen appropriately" Hellwig (2010) claims, the figure proves to be useless. Hence, banks may have arrived to the first decade of the twenty first century with even little equity, which, according to Hellwig (2010), may have played an important role on the severity of the 2007-2008 financial crisis.

In short, it is possible to determine three main regulatory changes that, while intended to increase banks' safety net and preventing financial crisis, may have contributed to the overall decline in banks' capital ratios (Berger, Herring and Szegö, 1995; Herring, 2011). The first was the creation of an institution to regulate and monitor the usage of long term assets as a collateral (e.g. public debt) to access short-term liquidity, as the OCC in the United States (Berger, Herring and Szegö, 1995). While reducing the concerns about asymmetric information, the establishment of this regulatory body

resulted in an additional source of confidence in the system (Herring, 2011). The second important regulatory change was the establishment of a role of lenders of last resort for central banks, which were able to provide additional liquidity to the system, helping the reduction of risk of financial distress and therefore, creating incentives to diminishing bank's capital ratios. A third regulatory change that may also help to explain the continuing overall declining trend on banks' leverage ratio was the introduction of government deposit guarantees. Again, as public policies tried to strengthen the safety net on the banking system, banks continued to increase their leverage ratio because "implicit government guarantees, as well as underpriced explicit guarantees, constitute a distortion that favors debt over equity financing for many financial institutions" (Admati et al., 2010). A similar argument was also made by Geanakoplos (2010). And even when regulation tried to set minimum capital ratios, as the Basel Capital Accord with a system of risk calibrated capital requirements, banks were able to continue increasing their leverage (Hellwig, 2010). However, the argument that regulation has somehow molded banks' capital ratio is also a matter of debate. Gropp and Heider (2010) claim that banks tend to optimize their capital ratios as any other non-financial firm does. Additionally, the authors did not find any empirical evidence of the impact of government deposit guarantee on leverage as well. Berger et al. (2008) argue that banks choose target capital ratios above regulatory minimum. Thus, although the declining trend on banks' capital ratios over the last 150 years has been accompanied by the strengthening of the safety nets designed to protect the financial system, there seems to exist empirical evidence that both equity holders and bond holders internalize some of the costs and benefits of the chosen capital structure. Meanwhile, Haldane (2010) suggests that the internalized costs and benefits do not include all the damage on the economy from a financial crisis. The optimal approach to do so is an ongoing debate. Tuner (2010) suggests that besides counter-cyclical macro-prudential rules, the most important driver of regulation on banking should be an increase of capital requirements of the banking system as a whole. However, it is also understood that raising equity levels comes with costs associated to it, such as an increase in the cost of funds in normal times (Kashyap, Rajan and Stein, 2008). Thus, in the next chapter we will analyze the extent to which capital requirements imposed on banks truly affect their efficiency.

2.3. Capital regulation: does it impact banks' efficiency?

As we described early, capital is important because it acts as a loss absorber. This feature is particularly vital on the banking industry due to the externalities that a bank failure may cause on the economy. However, the long-run global trend on banks' capital ratio has been towards an increase in leverage. Although this increasing trend has been interrupted due to regulation on leverage and/ or on minimum capital requirements, the 2007-2008 crisis has shown that bank capital was not enough to keep trust on interbank markets (Hellwig, 2010). Despite of its importance to the soundness of the financial system, setting higher equity requirements – or less leverage – generates a lot of controversy in the industry, among public policymakers, and among regulators. Even in the academia, this topic is a matter of continuous research and debate. For Admati et al. (2010), "capital regulation can be a powerful tool for enhancing the role of banks in the economy" and "given the experience of the 2007-2008 crisis, it is natural to consider a requirement that banks have significantly less leverage" which can be understood as setting a higher capital requirement so that assets volatility does not cause distress or insolvency. BIS (2010b) have also conducted a study on the long-term economic impact of an increase in capital and liquidity requirements. Although this research has concluded that the net benefits on the output level would be positive – due to estimated positive effects of reducing the probability and severity of banking crisis – BIS (2010b) observed that higher capital requirements will increase lending spreads and, consequently, the overall economy borrowing costs. The BIS assumption is that equity finance is more expensive than debt finance and that the cost of equity and the cost of debt are not affected by the change in the riskiness of the bank.

But before we analyze the extent to which banking efficiency can or cannot be affected by setting higher capital requirements, lets us first briefly identify what are the major objectives of capital regulation. According to Kashyap, Rajan and Stein (2008), there are four key goals which capital regulation tends to pursue: protecting depositors and the rest of the economy from bank failure; align incentives between managers and shareholders, because the latter will monitor the former to guarantee that no additional risk is being taken; high capital charges for riskier assets, since capital is understood to be a preferred way of financing (this has led to the use of risk weighted assets approach so that a bank that invests in riskier assets would not be favored with the same financing cost than a bank which invests on safer assets); and impose market discipline on banks.

As the collapse of Lehman Brothers in 2008 has shown, financial stress in one large institution can easily spread around, "causing a credit crunch or an asset price implosion (Admati et al., 2010). So capital regulation tries to set minimum capital requirements that hopefully will minimize the risk of such happenings, since equity acts as a loss absorber. In what concerns aligning incentives between managers and equity holders, when managers are compensated based by return on equity, there may be the temptation to choose riskier assets – with expected higher returns – in order to achieve special bonuses. Setting minimum capital requirements will put a threshold on leverage which the management team cannot exceed. Since banks treat capital as an expensive way of financing their activity, without a model that allows differentiating among riskier assets, relatively safe borrowers will not find financing in any bank. Attributing different risks to assets will, in theory, allow capital consumption to be higher when risk is higher (Kashyap, Rajan and Stein, 2008), hence creating incentives for banks to have less risk. The forth objective of capital regulation is to impose market discipline on banks. When a bank faces an adverse shock, having a minimum capital requirement to comply with will make any necessary adjustment clear and "can be said to impose a type of market discipline on banks" (Kashyap, Rajan and Stein, 2008).

Besides the objectives of setting minimum capital requirements explained previously, it is also understood that placing constrains on bank's capital structure will impact banks' efficiency. Several arguments are commonly stated by the industry as well as by the academia. Let us group those arguments in three classes: those that harm efficiency due to the impact on the provision of financial services; a second set that harm efficiency due to the properties of debt; and third group of arguments based on asymmetric information theories.

Among the first class of arguments is that setting higher capital requirements for banks will not only diminish the capacity of banks to provide financial services, namely providing less loans to the economy or accepting less deposits (Van den Heuvel, 2008), but will also push banks to operate at a suboptimal level. Yet, Admati el al. (2010) argues that this claim "confuses the two sides of the balance sheet", since equity, besides acting as a loss absorber, represents one way of funding banking activities and not "money that banks must be set aside" (Admati et al., 2010). Hence, in what concerns the impact of capital requirements on the capability of banks "issuing deposit-type liabilities" (Van den Heuvel, 2008), i.e. the amount of financial services provided,

Admati et al. (2010) defend that there are three kind of strategies a bank may follow, while still complying with an increase on capital requirements. One may be through balance sheet reduction, which indeed may lead to a decrease in the amount of loans conceded and deposits taken. A second approach that may be followed to achieve the necessary deleverage is holding the size of the balance sheet fixed, while increasing the amount of equity which finances it, by decreasing debt. Finally, a third alternative strategy involves the expansion of a bank's balance sheet, funding it exclusively with equity until the required leverage is fulfilled. Therefore, as the second and third examples demonstrate, increasing capital requirements does not necessarily lead to a decrease in the provision of financial services.

Regarding the consequence of setting higher regulatory equity requirements on the efficient provision of financial services, such claims are backed by the cost of equity. "If capital were cheap, banks would be extremely safe because they would hold high levels of capital, providing full protection against even extreme events" (Elliot, 2009). However, Admati et al. (2010) claim that this kind of argument "reflects a misunderstanding of the way in which risks affect the cost of funding". The required expected return on equity is higher than the required expected return on debt reaches out to support the argument that funding operations with equity is more expensive than funding the asset side of the balance sheet with debt. Hence, the argument goes, a banks' capital structure which holds a greater amount of capital will have a higher average cost of funding. Yet, the required expected return on equity is higher because it reflects the inherent riskiness of equity – as a residual claim on banks total assets – when compared to debt – which is a hard claim on total assets. In this sense, the higher a bank's leverage, the higher will be the required expected return from equity holders. And as bond holders assess leverage as a sign of risk, the expected return on debt may also increase with leverage. The opposite may also hold. If a bank is funded with more equity, the riskiness of cash-flows may indeed be translated into less risk for shareholders (Admati et al., 2010). Consequently, the risk premium demanded may be reduced. The same may also apply to debt and the required rate of return by bondholders. This is what Modigliani and Miller (1958) have shown when stated that despite all deviations resulting from market imperfections (e.g. taxes), the true financing cost should reflect the riskiness of the assets, not the financing mix that was used. Therefore, even though all the tax advantages and implicit public subsidies on debt that

are in place, setting higher capital requirements needs not necessarily imply a higher funding cost to the banking industry (Admati et al., 2010).

The two aforementioned arguments are somehow based on suboptimal provision of financial services and also on not taking advantage of the public framework and regulation that treat equity financing less favorably than debt financing. Both may harm banks' efficiency. Let us now review a second set of arguments that are based on the properties of debt and its contribution for reducing frictions among banks' different stakeholders. The first characteristic of debt is its role as an informational insensitive security. "Debt is the optimal security for trade in funding markets because it is least information sensitive and thus best in maintaining symmetric ignorance" (Dang, Gorton and Holmström, 2013). So, setting higher capital requirements will contribute to the diminishing of the debt amount that banks may issue, and consequently, will impact the access to overall liquidity since "only debt-like securities are considered as cash equivalents and the only instruments traded in funding markets" (Dang, Gorton and Holmström, 2013). Therefore, less debt being issued will also mean less liquidity in the markets, and consequently, banks will be less efficiently managed. However, this property may no longer hold if there is a significant prospect of failure (Gorton, 2009; Admati et al., 2010). If the possibility of default is real, as happened recently with 2007-2008 financial crisis, debt may become "informationally-sensitive, that is, subject to adverse selection because the shock creates sufficient uncertainty as to make speculation profitable" (Gorton, 2009). So we might even say that the greater the bank leverage, the more exposed to adverse shocks the bank will be. As leverage may drive the debt issued by a bank to the collapse, it may not be conclusive that raising equity levels may harm banks' efficiency by diminishing the amount of informational insensitive securities issued.

A second important property of debt is the disciplinary role over management. Since setting higher capital requirements may reduce leverage, this may turn into the emergence of governance issues that could lead to less efficiency on management and consequently on banks' performance. Admati et al. (2010) has gathered the two main lines of arguments that sustain the importance of debt on management discipline: debt, as a hard claim, forces management to reduce waste; and debt-finance eliminates moral-hazard and management risk taking behavior due to the threat of non-rolling existing debt. Since debt claims are fully specified in advance, they represent a very strong

commitment to the management team. Hence, "short-term creditors are better protected against the actions of wayward bank management (…) and the tendency for banks to finance themselves largely with short-term debt may reflect a privately optimal response to governance problems" (Kashyap, Rajan and Stein, 2008). Plus, besides being able of paying the existing debt, banks face an additional pressure to renew debt at maturity. According to Calomiris (1999), "the key to market-discipline approach is placing private parties at risk with respect to undesirable behavior by banks". And this is achieved using subordinated debt (Calomiris, 1999). The argument is that if banks take excessive risk or manage their assets poorly, they will not be able to renew subordinated debt and will be forced to shrink their balance sheets or issue new equity (Calomiris, 1999). The assumption behind such statement is that management will have to be very careful and efficient because otherwise their debt will not be rolled over by existing creditors. However, as the recent financial crisis has shown, the kind of governance problems that may worry equity holders are those related to excessive risk tanking, which may be extended with leverage combined with public safety nets (Admati et al., 2010). Adrian and Shin (2010) have shown that leverage is strongly procyclical and the major United States investment banks were highly leveraged before the 2007-2008 crisis. Gropp and Heider (2010) found that in the period between 1991 and 2004, banks have financed balance sheet growth with non-deposit liabilities, and accordingly to Admati et al. (2010), before the 2007-2008 crisis there was a continuous increase on short-term debt, namely repo contracts, which were continuously renewed without bringing any disciplinary role over management. More than monitor banks' efficiency, short-term lenders seemed to be guided by public information as downgrades of mortgage backed securities and of collateralized debt obligations by rating agencies (Admati et al., 2010). "Thus, debt only directly provides true discipline in the extreme scenario in which refinancing the debt is infeasible due to clear insolvency or sufficient uncertainty regarding insolvency to induce market failure" (Admati et al., 2010). Once again, it is not clear that setting higher capital requirements will indeed harm banks' efficiency in the long run.

We have analyzed why increasing capital requirements may harm banks' efficiency due to its impact on the provision of financial services and due to the disciplinary properties of debt. Let us now turn to a third category of claims that are related to asymmetric information theories (Bolton and Freixas, 2006). Since bank managers know more about

their company's current earnings and investment opportunities than outside investors, markets will buy new equity issues only at a large discount from their equilibrium values without informational asymmetries. Additionally, as "banks are more difficult to understand for outside investors, it is possible that the costs of issuing equity may be higher" (Gropp and Heider, 2010). Hence, managers will issue stock, or undertake other leverage-decreasing activities, only if they are forced to do so by an earnings shortfall, or if voluntarily acting in the pursuit of their own interests. "Thus, because of information asymmetries about the true value of bank assets, there is an endogenous cost of equity and, by extension, an endogenous cost of bank lending" (Bolton and Freixas, 2006). However, this negative effect may be neutralized if discretion was, somehow, eliminated. Admati et al. (2010) uses the Troubled Asset Relief Program in 2009 as an example of regulation which overcomes the asymmetric information issue, since it would be mandatory for all banks. Additionally, banks with less leverage may be able to generate more profits because they have less interest to bear, leaving more earnings to finance the left-hand side of the balance sheet (Admati et al., 2010).

In short, after reviewing the main purposes of capital regulation, we revisited a set of arguments commonly used either by the industry or by the academia to justify why capital requirements are associated to banking inefficiency. However, before we move on to a synthesis of empirical findings on this subject, let us make a small reference to the Swedish banking industry. After the country 1990s banking crisis, Sweden has imposed "some of the highest capital ratios in the rich world" (The Economist, 2013b). Though regulatory authorities have established a minimum Tier I capital ratio of 12%, "Swedish banks are generating among the highest returns on equity among rich-world banks" (The Economist, 2013b). Hence, raising capital requirements may neither be the necessary nor the sufficient condition to decrease profitability in the banking industry. On the contrary, it may even act as an incentive to improve efficiency in the sector (Eavis, 2013). Let us then have an overview on empirical and theorethical findings on capital regulation and banking efficiency.

2.4. Capital regulation, equity and banking activity: empirical and theoretical findings

We have analyzed the role of capital in banks' financing mix, the historical evolution of banks' capital structure and the theoretical impact of capital regulation on banks' efficiency. Nevertheless, to have a clear view on how capital regulation impacts banks

activities, let us first address two questions: "what do commercial banks do?" and "why, as organizations, should banks perform better than any other organization in doing what they do?" According to Hughes and Mester (2008), "the literature on financial intermediation suggests that commercial banks, by screening and monitoring borrowers, can solve potential moral hazard and adverse selection problems caused by the imperfect information between borrowers and lenders". This is what allows banks to write financial contracts and monitor contractual performance. Hughes and Mester (2008) highlight banks' ability to improve information asymmetries between lenders and borrowers derived from information collected on borrowers, which allows managing risk and monitoring credit performance more efficiently. That is why banks do what they do better than any other kind of lender.

However, the way banks perform more or less efficiently these activities depends on many factors. Calomiris and Khan (1991) highlight the importance of demandable debt in the financing of banks' activities, "in an environment of asymmetric information with potential for fraudulent behavior on the part of the banker". Hughes, Mester and Moon (2001) argue that "banks' unique capital structure is the source of their competitive advantage in producing information-intensive loans and financial services". On the other hand, Hughes and Mester (2008) emphasize "property rights, legal, regulatory, and contracting environments in which banks operate" as the main drivers of banks' efficiency.

So, assuming that in fact regulation may impact the way banks operate efficiently, let us summarize the major empirical and theoretical findings that have been found about regulation on equity and banking activity. The literature on this topic is extensive, but somehow contradictory. Therefore, it is possible to group the main empirical findings in three distinct impacts on banking efficiency: those who have found empirical evidence that regulation on capital requirements negatively affects banks' efficiency; those who have concluded that regulation may indeed help banks' performance; and those who did not find any impact of regulation on banks' activities.

Starting with authors that have found evidence that regulation on capital requirements harm banks' efficiency, VanHoose (2007) made a literature review on the impact of capital regulation on banking activities. Although there does not seem to exist a consensus on the subject, the author concluded that "the immediate effects of

constraining capital standards are likely to be a reduction in total lending and accompanying increases in market loan rates and substitution away from lending to holding alternative assets" (VanHoose, 2007). Hence, banks will operate in a suboptimal level, transferring these inefficiencies to the real economy. Hellmann, Murdoch and Stiglitz (2000) conducted an experiment to assess if an increase on capital requirements would lead banks to Pareto equilibrium. The authors concluded that although capital requirements reduce gambling incentives, they increase the potential scope for gambling in a multi-period time-frame. Therefore, no Pareto equilibrium will be achieved, i.e., increasing capital requirements will lead banks to operate less efficiently. Van den Heuvel (2008) designed a framework to measure what are the costs associated with increasing capital requirements. Although the author recognizes that capital requirements "limit the moral hazard on the part of banks that arises due to deposit insurance", it concluded that "this capital requirement is also costly because it reduces banks' ability to create liquidity in equilibrium" (Van den Heuvel, 2008). Again, forcing banks to operate at a suboptimal level will lead to inefficiencies, impacting the economy as a whole.

On the opposite side, there are also authors that found empirical evidence that regulation on equity may help in improving banks' efficiency. Berger (1995) studied the relationship between capital and earnings using 1983-1989 data. The author found that the book value of capital to asset ratio is positively related to the return on equity of United States' banks. Berger (1995) suggested that these results are consistent with the expected bankruptcy costs hypothesis. Other important result was found by Beltratti and Stulz (2009). The researchers concluded that "banks that had higher Tier I capital ratio in 2006 and more deposits generally performed better during the crisis" (Beltratti and Stulz, 2009), which may be in line with the role of capital as a cushion to absorb losses. The authors also found that bank specific characteristics and risk taking behavior seemed to have a greater explanatory power than regulation. Dietsch and Lozano-Vivas (2000) conducted a study on the impact of the economic environment on banks' efficiency comparing two countries – France and Spain. The authors concluded that there is a negative relation between the capital ratio and banking costs i.e., better capitalized banks tend to produce financial services less costly. According to the authors, the explanation could be "the existence of a negative relationship between bank risk and bank borrowing costs" (Dietsch and Lozano-Vivas, 2000). Also on the same

subject and arriving to the same conclusions, Pasiouras, Tanna and Zopounidis (2009) conducted a study on the impact of regulation on commercial banks activities. The paper included data from banks operating in 74 countries and the authors concluded that stricter capital requirements may improve cost efficiency due to two main factors: lowering the probability of financial distress, it reduces the risk premium charged to the bank by debt holders; and diminishing the interest payments since the activities are now financed with more equity.

Mehran and Thakor (2011) have developed a model to analyze the trade-off between costs and benefits of capital on banks. The authors concluded that "total bank value as well as various components of bank value is positively correlated with bank capital in the cross-section" (Mehran and Thakor, 2011). Also relevant may be the impact on banks' efficiency of debt overhang. Admati et al. (2012) have analyzed the incentives to reduce leverage of a firm that has high levels of debt. The researchers found out that due to the debt overhang effect, high leverage banks will indeed benefit from setting higher capital requirements. The reason is that when leverage is high, management will have no incentives to recapitalize, even if that option will be the one that maximizes banks' total value.

Finally, as aforementioned, it is also possible to find in the literature empirical findings that regulation may not impact banks' activities or efficiency at all. Barth, Caprio and Levine (2004) used a database on bank regulation and supervision in 107 countries. The authors did not find any robust relationship between capital requirements and banking activities in a cross-country analysis. On their review of the evolution of the same World Bank survey on bank regulation – updated in 2011 –, the same authors concluded that "while many have followed the Basel guidelines and strengthened capital regulations and empowered supervisory agencies, existing evidence does not suggest that this will improve banking-system stability, enhance the efficiency of intermediation, or reduce corruption in lending" (Barth, Caprio and Levine, 2012). These findings were not influenced by any particular institutional environment. Laeven and Levine (2009) have also studied the impact of corporate governance and national laws and regulation on banking activities, namely risk taking. The researchers concluded that "standard bank regulations, such as capital requirements, supervisory oversight, and prompt corrective action policies, do not directly influence risk taking"

(Laeven and Levine, 2009), emphasizing the role of corporate governance rather than regulation on banking activities.

So, impact of capital regulation on banks' activities and efficiency is a matter of controversy and distinct empirical findings support different views on the subject. Therefore, due to the relevance of the topic, there seems to be both need and opportunity to contribute to this topic even further, especially at a time when bank regulation is under debate and the 2007-2008 financial crisis showed that improvements can be made. Thus, in the next chapter we will move forward to present the methodology that was used to conduct our study on capital requirements and banks' efficiency.

Chapter 3 | Method

3.1. Model description

According to Hughes and Mester (2008), there are two broad approaches to explain banks' performance. The nonstructural approach uses "a variety of financial ratios that capture various aspects of performance, while the structural approach, "relies on a theoretical model of the banking firm and a concept of optimization" (Hughes and Mester, 2008). The former investigate technology by trying to find correlation between performance and investment strategies or focusing on bank's product mix, or correlation between performance and the quality of bank's governance (Hughes and Mester, 2008). The latter focus on the role of banks "as a financial intermediary that produces informationally intensive financial services" and it "usually relies on the economies of cost minimization or profit maximization" (Hughes and Mester, 2008). As Berger and Humphrey (1992), Berger and Mester (1997), Dietsch and Lozano-Vivas (2000), Maudos et al. (2002), Pasiouras, Tanna and Zopounidis (2009), among others, we will follow the structural approach for this research. Two different efficiency concepts will be specified and studied: the cost efficiency and the alternative profit efficiency. According to Maudos et al. (2002), it has been observed that banks of similar size do not necessarily have the same average costs. Therefore, cost efficiency analysis "has been a much more important potential source of cost reduction than the achievement of an optimum size of production for minimizing average costs" (Maudos et al., 2002). The cost efficiency function uses a vector of input prices and output levels. It assumes that the observed output level is already profit maximizing (Berger and Humphrey, 1997). However, minimizing costs is not a sufficient condition to achieve profit efficiency. Hence, it will be useful modeling a profit frontier to evaluate the impact of capital regulation on this dimension as well. It will be used the alternative profit concept instead of the profit concept because the former suits better in cases where there are significant differences in the size of banks in the sample and also in situations where firms exercise some market power (Berger and Mester, 1997). Furthermore, Maudos et al. (2002) and Kasman and Yildirim (2006) pointed out that the alternative profit efficiency is more appropriate when international comparisons are being made because it accommodates different competition degrees and the impact of output quality on revenues, which is also the case. The alternative profit frontier uses also a vector of input prices and output levels. The cost efficiency and the alternative profit efficiency

concepts have also been applied in the literature by Berger and Mester (1997), Dietsch and Lozano-Vivas (2000), and Pasiouras, Tanna and Zopounidis (2009). Still, Berger and Mester (1997) have found "that the choices made concerning efficiency measurement usually make very little difference", concluding that "the efficiency estimates are fairly robust to differences in methodology".

Hereupon, we will assess the impact of regulatory capital requirements on banking efficiency using the Battese and Coelli (1995) stochastic frontier production function for panel data to estimate inefficiency effects. This model "provides estimates of efficiency in a single-step in which firm effects are directly influenced by a number of variables" (Pasiouras, Tanna and Zopounidis, 2009). According to Battese and Coelli (1995), early papers on stochastic frontier production functions adopted a two-stage approach in which the stochastic frontier was estimated in the first step and the inefficiency terms were estimated in a second step. However, Coelli et al. (2005) highlight that using a single step model makes the second step unnecessary. Additionally, if environmental variables are excluded in the first step, it will lead to biased estimators for the deterministic part of the frontier. As a consequence, one will also obtain biased estimations for the efficiency terms as well. As aforementioned, our purpose is to compare the impact of different capital regulation applied among countries. Therefore, as described by Berger and Humphrey (1997), the efficiency frontiers will be "formed from the complete data set across nations allowing for a better comparison across nations, since the banks in each country would be compared against the same standard". According to Pasiouras, Tanna and Zopounidis (2009) this approach will "allow the estimation of a global frontier while accounting for cross-country differences". Hence, consider the following general form for the cost model for panel data:

$$\ln C_{i,t} = C\left(q_{i,t}, p_{i,t}; \beta\right) + v_{i,t} + u_{i,t}, \quad i = 1, 2, \dots, N; t = 1, 2, \dots, T \qquad (1)$$

where $C_{i,t}$ is the bank i total cost at time t; $q_{i,t}$ is the outputs vector; $p_{i,t}$ designates a vector of input prices specified according with a suitable functional form; β is a vector of unknown parameters to be estimated; $v_{i,t}$ are random errors, assumed to be i.i.d. and have $N(0, \sigma_v^2)$; and $u_{i,t}$ are the nonnegative inefficiency effects in the model which are assumed to be independently (but not identically) distributed, such that $u_{i,t}$ is obtained by truncation (at zero) of the $N\left(m_{i,t}, \sigma_u^2\right)$ distribution where the mean is defined by:

$$m_{i,t} = z_{i,t}\delta \qquad (2)$$

where $z_{i,t}$ is a $(1 \times M)$ vector of observable explanatory variables that influence the efficiency of bank i at time t; and δ is an $(M \times 1)$ vector of coefficients to be estimated. In the cost model, the inefficiency term defines how far banks conduct their activities above the cost frontier (Coelli, 1996).

The alternative profit model for panel data can be described as:

$$\ln P_{i,t} = P(q_{i,t}, p_{i,t}; \beta) + v_{i,t} - u_{i,t}, \quad i = 1,2,\dots,N; t = 1,2,\dots,T \qquad (3)$$

where $P_{i,t}$ is the bank i profit at time t. All the remaining parameters of the alternative profit model take similar descriptions to the cost model, as well as $u_{i,t}$ for the nonnegative inefficiency effects. In the alternative profit model, the inefficiency effects determine how far banks operate below the profit frontier (Coelli, 1996). Again, as in the cost model, $u_{i,t}$ is obtained by truncation (at zero) of the $N(m_{i,t}, \sigma_u^2)$ distribution where the mean is defined by:

$$m_{i,t} = z_{i,t}\delta \qquad (4)$$

where $z_{i,t}$ and δ are defined as abovementioned. The parameters of equations (1), (2), (3), and (4) are estimated in one step using maximum likelihood according to the Battese and Coelli (1995) specification, as described in Coelli (1996). Individual bank inefficiency scores were computed from the estimated frontiers. The measures of cost efficiency relative to the cost frontier are defined as:

$$CE_{k,t} = exp(u_i) \qquad (5)$$

and will take a value between one and infinity. In the case of the measure of the alternative profit efficiency relative to the alternative profit frontier, it will be computed as follows:

$$PE_{k,t} = exp(-u_i) \qquad (6)$$

and will take values between zero and one. As Pasiouras, Tanna and Zopounidis (2009), to make comparisons easier, we will calculate the cost efficiency index as:

$$CEI_{k,t} = 1/CE_{k,t} \qquad (7)$$

Hence, both profit and cost will assume values between zero and one, and the closer the score is to one, the higher the efficiency level.

Concerning the efficiency frontier specifications, it will be followed the structural approach, using output levels and input prices (Berger and Mester, 1997). As Dietsch and Lozano-Vivas (2000), Maudos et al. (2002), and Pasiouras, Tanna and Zopounidis (2009), it was followed the value added approach, which "considers all liability and asset categories to have some output characteristics rather than distinguishing inputs from outputs in a mutually exclusive way" (Berger and Humphrey, 1992). Therefore, as Pasiouras, Tanna and Zopounidis (2009) and others, we have chosen the following outputs: loans (Q1), other earning assets (Q2), and total deposits – customer and interbank – (Q3). Because there is controversy in the literature regarding the variable deposits being defined as an output in efficiency models (Hughes, Mester and Moon, 2001), we have also specified two parallel frontiers which will be discussed later. Also consistently with research on banking efficiency, we have chosen three inputs prices: cost of borrowed funds (P1), computed as the ratio of interest expense on total deposits plus long-term debt; cost of physical capital (P2), derived as the ratio of general and administrative expenses (excluding salaries and employee benefits) on net fixed assets; and cost of labor (P3) calculated by dividing salaries and employee benefits on total assets. Similar approaches were followed by Dietsch and Lozano-Vivas (2000), Maudos et al. (2002), and Pasiouras, Tanna and Zopounidis (2009).

As dependent variables, the cost frontier model will use the sum of interest expense and non-interest expense as banks' total cost (TC), and the alternative profit frontier model will use, as dependent variable, the profit before taxes (PBT). As commonly followed in the literature, linear homogeneity restrictions were imposed by normalizing the dependent variables TC and PBT and all input prices P1, P2, and P3 by the third input price (P3). Besides input prices and output levels, as Pasiouras, Tanna and Zopounidis (2009), we use a year dummy variable in both cost and alternative profit frontiers to account for changes in technology over time. Moreover, as Berger and Mester (1997) and Pasiouras, Tanna and Zopounidis (2009), we use equity (E) to control for "different risk preferences on the part of banks" (Berger and Mester, 1997). Finally, also for controlling differences on the banks' size in the spirit of Maudos et al. (2002), it was added to both cost and alternative profit frontiers the variable total assets (A). As Maudos et al. (2002), Fries and Taci (2005), Pasiouras, Tanna and Zopounidis, (2009),

and others, we will use the multi-product translog specification which results in the following empirical cost frontier model:

$$\ln\left(\frac{TC}{P_3}\right) = \beta_0 + \beta_1 \ln(Q_1) + \beta_2 \ln(Q_2) + \beta_3 \ln(Q_3) + \beta_4 \ln\left(\frac{P_1}{P_3}\right) + \beta_5 \ln\left(\frac{P_2}{P_3}\right) +$$

$$\beta_6 \frac{1}{2}(\ln(Q_1))^2 + \beta_7 \ln(Q_1)\ln(Q_2) + \beta_8 \ln(Q_1)\ln(Q_3) + \beta_9 \frac{1}{2}(\ln(Q_2))^2 +$$

$$\beta_{10}\ln(Q_2)\ln(Q_3) + \beta_{11}\frac{1}{2}(\ln(Q_3))^2 + \beta_{12}\frac{1}{2}\left(\ln\left(\frac{P_1}{P_3}\right)\right)^2 + \beta_{13}\ln\left(\frac{P_1}{P_3}\right)\ln\left(\frac{P_2}{P_3}\right) +$$

$$\beta_{14}\frac{1}{2}\left(\ln\left(\frac{P_2}{P_3}\right)\right)^2 + \beta_{15}\ln(Q_1)\ln\left(\frac{P_1}{P_3}\right) + \beta_{16}\ln(Q_1)\ln\left(\frac{P_2}{P_3}\right) + \beta_{17}\ln(Q_2)\ln\left(\frac{P_1}{P_3}\right) +$$

$$\beta_{18}\ln(Q_2)\ln\left(\frac{P_2}{P_3}\right) + \beta_{19}\ln(Q_3)\ln\left(\frac{P_1}{P_3}\right) + \beta_{20}\ln(Q_3)\ln\left(\frac{P_2}{P_3}\right) + \beta_{21}\ln(E) +$$

$$\beta_{22}\frac{1}{2}(\ln(E))^2 + \beta_{23}\ln(E)\ln(Q_1) + \beta_{24}\ln(E)\ln(Q_2) + \beta_{25}\ln(E)\ln(Q_3) +$$

$$\beta_{26}\ln(E)\ln\left(\frac{P_1}{P_3}\right) + \beta_{27}\ln(E)\ln\left(\frac{P_2}{P_3}\right) + \beta_{28}\ln(A) + \beta_{29}\frac{1}{2}(\ln(A))^2 +$$

$$\beta_{30}\ln(A)\ln(Q_1) + \beta_{31}\ln(A)\ln(Q_2) + \beta_{32}\ln(A)\ln(Q_3) + \beta_{33}\ln(A)\ln\left(\frac{P_1}{P_3}\right) +$$

$$\beta_{34}\ln(A)\ln\left(\frac{P_2}{P_3}\right) + \beta_{35}\ln(A)\ln(E) + \beta_{36}D2004 + \beta_{37}D2005 + \beta_{38}D2006 +$$

$$\beta_{39}D2007 + \beta_{40}D2008 + \beta_{41}D2009 + \beta_{42}D2010 + \beta_{43}D2011 + v_{i,t} + u_{i,t} \quad (8)$$

In the above expression, the logarithm of the cost of production is function of a vector of input prices (P1, P2, and P3) and outputs (Q1, Q2, and Q3), while controlling for bank size (A), leverage (E), and yearly technological evolution (year dummies). The $u_{i,t}$ is interpreted as technical inefficiency effects which cause banks to operate above the stochastic cost frontier. The alternative profit frontier model will follow the same specification as the cost frontier model, but with $\ln\left(\frac{PBT}{P_3}\right)$ as dependent variable and the inefficiency term $u_{i,t}$ preceded by a minus sign – since we are trying to determine how below the efficient frontier bank i is operating. In both the cost frontier and the alternative profit frontier, the inefficiency term is a function of regulatory variables – CAPTRQR, OFFDPWR, MKTDISC, and ACTRSTR –, of macroeconomic conditions – INFLATN and GDPGRCP –, of financial development variables – DCPSGDP and MKTCGDP –, of the environmental framework – FOREIGN, GOVERN, CONCENT, and DEVELOP –, and of bank specific variables – ROA, LTD, LLT, ETA, and CTI.

In equations (2) and (4), $m_{i,t}$ will be specified as:

$$m_{i,t} = \delta_0 + \delta_1 CAPTRQR + \delta_2 OFFDPWR + \delta_3 MKTDISC + \delta_4 ACTRSTR +$$
$$\delta_5 INFLATN + \delta_6 GDPGRCP + \delta_7 DCPSGDP + \delta_8 MKTCGDP + \delta_9 FOREIGN +$$
$$\delta_{10} GOVERN + \delta_{11} CONCENT + \delta_{12} DEVELOP + \delta_{13} ROA + \delta_{14} LTD + \delta_{15} LLT +$$
$$\delta_{16} ETA + \delta_{17} CTI$$

(9)

where CAPTRQR is an index of regulatory capital requirements; OFFDPWR is a measure of power of the supervisory agencies, MKTDISC is an indicator of market discipline, and ACTRSTR refers to the level of restrictions imposed on banking activities. Combined, and besides capital requirements, these three later variables control for the regulatory framework.

We will now discuss briefly these regulatory variables – capital requirements plus the regulatory control variables –, while detailed information on how each regulatory variable was effectively built is provided in Appendix I. Inputs for regulatory variables were obtained in the Bank Regulation and Supervision Survey (BRSS), carried out by the World Bank. This survey aims to collect information on regulation and supervisory practices on more than 100 countries, allowing cross-country comparisons. The data is collected from national regulatory authorities and was first released in 2001, being subsequently updated in 2003, 2007, and 2011. Therefore, beside cross-country comparisons, it also allows examining regulatory trends and how supervision authorities react to meaningful economic events. The last version of the survey gathers some 270 questions on subjects as capital, auditing requirements, governance, etc. That said, CAPTRQR is an index of capital requirements and includes questions from both initial and overall capital stringency as in Barth, Caprio and Levine (2004), and Pasiouras, Tanna and Zopounidis (2009). According to Barth, Caprio and Levine (2004), initial capital stringency tries to reflect what kind of funds can be used to finance banking activity initially and if the regulatory authorities validate the different sources. Overall capital stringency variables include questions which aim to indicate "whether the capital requirement reflects certain risk elements and deducts certain market value losses from capital before minimum capital adequacy is determined" (Barth, Caprio and Levine, 2004). Since the BRSS 2011 has updated some questions of the BRSS 2007, in order to maintain comparability between both surveys, CAPTRQR will take values between 0-6 – and not between 0-8 as in Barth, Caprio and Levine (2004), and Pasiouras, Tanna and Zopounidis (2009) – with higher values meaning more stringent capital requirements.

OFFDPWR is a measure of the power of the supervisory authorities in each country and tries to indicate "whether the supervisory authorities have the authority to take specific actions to prevent and correct problems" (Barth, Caprio and Levine, 2004). The variable can take values between 0-12 to keep a degree of consistency between the 2007 and the 2011 surveys. Higher values indicate greater power of the supervisory authorities. MKTDISC is a measure of market discipline and can take values between 0-8, with 8 meaning higher disclosure obligations and greater incentives to private monitoring (Pasiouras, Tanna and Zopounidis, 2009). For the variables CAPTRQR, OFFDPWR, and MKTDISC the final value was obtained by the summation of the qualified answers as in Barth, Caprio and Levine (2004), Pasiouras, Tanna and Zopounidis (2009), and Barth, Caprio and Levine (2012). Finally, ACTRSTR is an indicator of the restrictions imposed on banking activities. Variables can take values between 1-4, being 1 "unrestricted" and 4 "prohibited" and the final score will be the average value of the four activities monitored (Pasiouras, Tanna and Zopounidis, 2009).

INFLATN is the annual percent change in the consumer price index and GDPGRCP is the annual percent change on gross domestic product (GDP) at constant prices. Both variables control for macroeconomic conditions following the approach of Maudos et al. (2002), Kasman and Yildirim (2006), and Pasiouras, Tanna and Zopounidis (2009); DCPSGDP accounts for the share of domestic credit to private sector on GDP while MKTCGDP is the ratio of market capitalization of listed companies to GDP. Both control for financial development as in Barth, Caprio and Levine (2004), Kasman and Yildirim (2006), and Pasiouras, Tanna and Zopounidis (2009); FOREIGN is the percentage of foreign owned banks in the economy, GOVERN is the percentage of government owned banks operating in the country, and CONCENT is the assets of the three largest commercial banks as a share of total commercial banking assets. These three variables control for countries' market structure in the spirit of Caprio and Levine (2004), and Pasiouras, Tanna and Zopounidis (2009); DEVELOP is a dummy variable to control for the state of economic development as in Pasiouras, Tanna and Zopounidis (2009); ROA is bank return on assets, LTD is the percentage of loans to total deposits, LLT is the percentage of loan losses to total loans, ETA is the percentage of equity to total assets, and CTI is the efficiency ratio, measured as cost-to-income. All these five remaining variables were included as bank specific control variables in the spirit of Dietsch and Lozano-Vivas (2000), Maudos et al. (2002), Demirgüç-Kunt, Laeven and

Levine (2004), and Laeven and Levine (2009). We will detail how these variables were computed in the next section.

3.2. Data, assumptions and variables definition

To select the countries for our sample, we have picked those that have participated in the Bank Regulation and Supervision Survey (BRSS) conducted by the world bank. Starting from the countries included in the BRSS 2007 and 2011 and for which we were able to find data to compute all other country specific variables aforementioned, we arrive at a short-list of 65 countries. We then construct a sample considering all the publicly quoted commercial banks in Bloomberg that operate in those 65 countries. The focus on publicly quoted banks is supported by Laeven and Levine (2009) since it "enhances comparability" (Laeven and Levine, 2009). Additionally, according to Demirgüç-Kunt, Laeven and Levine (2004) selecting only commercial banks has two advantages: the regulatory data from the World Bank Surveys are about commercial banks, so there will be consistency between bank specific data and regulatory variables; and commercial banks tend to be more homogeneous in terms of services, and consequently on inputs and outputs. From the 65 countries, we obtained 1196 banks from Bloomberg. Then, it was excluded from our sample bank-year observations for which at least one of the bank-specific variables was missing. Our final sample comprises 156 banks from 30 countries, for which there is at least one year with bank specific variables in the period 2004-2012. This results in an unbalanced dataset of 865 bank-year observations (considering a specification slightly different, the dataset would increase substantially. We will address this topic later on when discussing the research limitations).

Excluding the ratios already computed by Bloomberg – return on assets and cost to income, which directly map the variables ROA and CTI – all the remaining bank-specific monetary variables were obtained from Bloomberg in USD. Since some banks in our sample have negative profits before taxes (i.e. losses) and negative equity, we follow a common approach in the literature (Kasman and Yildirim, 2006; Pasiouras, Tanna and Zopounidis, 2009) which consists on adding a constant to the extracted profits before taxes and equity values to assure that all values were positive, thus allowing natural logarithms to be taken. Calculation rules for each bank specific variable are fully detailed in the Appendix II. As Pasiouras, Tanna and Zopounidis (2009), we converted the amounts in real (2009) terms using a GDP deflator collected

from International Monetary Fund (IMF) – World Economic Outlook Database. Also from the IMF, it was collected the data for the macroeconomic variables, i.e., the annual percent change in the consumer price index, which will be used as the control variable INFLATN, and the annual percent change on GDP at constant prices, which will be used as the control variable GDPGRCP.

As detailed in the previous section, the regulatory variables on capital requirements, on power of the supervisory agencies, on market discipline and on restriction on banking activities – CAPTRQR, OFFDPWR, MKTDISC, and ACTRSTR – were computed with data from the BRSS 2007 and BRSS 2011. Since data is not available on an annual basis, it was assumed the BRSS 2007 score for the period 2004-2006 and the BRSS 2011 data for the remaining years of the analysis (2007-2012).

To control for the impact of financial development on banks' efficiency, it was collected data on domestic credit to private sector as percentage of GDP – DCPSGDP – and on market capitalization of listed firms (also as percentage of GDP) – MKTCGDP – from the World Bank database for the period 2004-2012.

The variables to control for market structure were obtained from two sources. The percentage of government owned banks operating in each country – variable GOVERN – was extracted from BRSS 2007 and BRSS 2011. Since data was not on an annual basis, it was followed the same approach as in the regulatory variables, i.e., data from the 2007 survey were applied to the period 2004-2006 and data from the 2011 survey were assigned to the 2007-2012 period. Data on bank concentration and on foreign owned banks in the market, variables CONCENT and FOREIGN respectively, were obtained from the World Bank database. The former had only data available for the period 2004-2011, so it was assumed for 2012 the values of 2011 or the latest. For the later, data was only available for the period 2004-2009, so the values from 2009 were also mapped to the period 2010-2012.

Finally, for the dummy variable which indicates the state of economic development between advanced and developing economies, it was used the IMF country classification. For more detail on how countries were distributed regarding state of the economy development and also geographical regions, please refer to Appendix III. In the next subsection we will present the characterization of the sample, both on bank specific and on country specific data.

3.2.1. Sample presentation

Our sample has 156 banks from 30 different countries. Overall, we have an unbalanced panel data of 865 bank-year observations. On our analysis period (2004-2012), it is possible to observe in our sample two different trends for total assets and equity mean book values (Figure 3 – amounts in $ millions expressed in real 2009 terms; assets and equity amounts are prior to any adjustment[1]). Until 2008, the sample average balance sheet has been increasing, peaking above $169 billion. After 2008, the amount of assets under management has been decreasing until 2011, and on average, has reached circa $133 billion, which is a reduction of more than 21%. In 2012, the sample average balance sheet has slightly expanded to $136 billion. In terms of equity book value, we can see that from 2004 to 2005, there was an increase in average leverage, since the amount of equity has declined while assets under management always increased in the period 2004-2008. In 2008, probably as a result from the 2007-2008 financial crisis, the average equity level dropped, after increasing in the period 2005-2007.

Figure 3 - Sample mean values by year | Assets and Equity
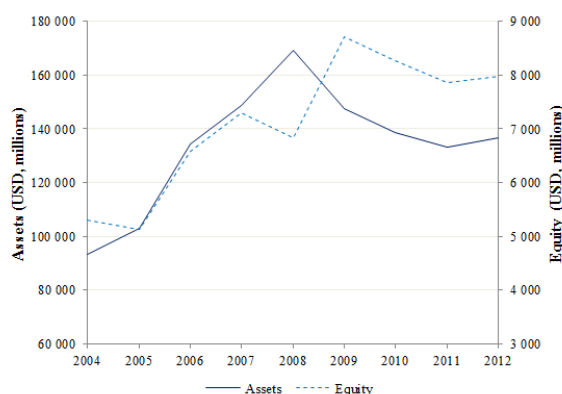
After 2008, average equity book value has followed a trend similar to total assets. However, at the end of the period, the implicit average leverage in our sample has declined from circa 17.6 to 16.1. Panel A and Panel B of Table 1 shows the sample average values by year and by geographical region for bank specific variables.

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[1] To compute efficiency frontiers, a constant was added to the extracted profits before taxes and equity amounts to assure that all values were positive, thus allowing natural logarithms to be taken.

Table 1 - Sample means of bank specific variables

	N	Q1	Q2	Q3	P1	P2	P3	TC	PBT	E	A
Panel A: means by year											
2004	55	51 184	32 771	59 808	0.0438	0.9151	0.0164	5 187	999	5 308	93 292
2005	66	49 037	42 194	67 075	0.0499	1.1287	0.0165	5 731	1 206	5 127	102 865
2006	78	61 151	57 679	86 107	0.0531	1.1937	0.0155	6 747	1 383	6 574	134 424
2007	101	62 671	63 557	93 213	0.0525	1.6231	0.0145	7 091	1 303	7 302	148 705
2008	105	71 743	53 436	92 183	0.0838	1.9933	0.0183	8 807	-5	6 835	169 265
2009	110	69 529	51 078	89 124	0.0492	1.2593	0.0149	5 721	782	8 717	147 391
2010	115	64 415	47 708	83 748	0.0421	1.2317	0.0156	4 868	981	8 273	138 526
2011	116	59 495	42 213	80 945	0.0548	1.3630	0.0177	5 267	647	7 853	133 314
2012	119	60 735	45 911	82 191	0.0487	1.3215	0.0171	4 765	235	7 969	136 554
Panel B: means by geographical region											
EUROAREA	194	144 902	101 875	179 429	0.0362	0.6366	0.0091	14 110	1 310	13 487	272 254
OTHERADVC	74	272 888	254 211	402 114	0.0154	0.6913	0.0071	17 840	2 227	35 683	742 778
DEVELASIA	209	4 882	2 884	7 255	0.0580	1.2834	0.0178	652	231	908	8 783
LATINA&C	226	17 794	14 005	23 861	0.0783	2.4526	0.0253	4 202	853	3 668	38 000
MEA	136	1 939	1 156	2 771	0.0544	1.2344	0.0151	253	75	343	3 538
EASTEURO	26	9 955	3 110	10 769	0.0372	0.8315	0.0119	776	195	1 759	14 136
TOTAL	865	62 276	49 227	83 389	0.0536	1.3719	0.0163	6 009	781	7 362	137 636

Notes:
Q1: Total loans; Q2: Other earning assets; Q3: Total deposits; P1: Cost of borrowed funds (Interest expense/ Total deposits + Long-term debt);
P2: Cost of physical capital (General and administrative expense/ Net fixed assets); P3: Cost of labor (Salaries/ Total assets); TC: Total cost (interest, non-interest);
PBT: Profit before taxes; E: Total equity; A: Total assets.
Q1, Q2, Q3, TC, PBT, E, A in $ millions expressed in real 2009 terms.
In assigning countries in regions it was followed the IMF Country classification - WEO Groups and Aggregates Information.

From the sample averages, it is possible to conclude that the credit granted has peaked in 2008, and has been declining from then until 2011. On average, the amount of loans in 2012 is less than in 2006. Although the bank-year observations are more concentrated on Latin America and Caribbean, and Developing Asia, the largest banks are those belonging to Advanced Economies (Euro Area and Other Advanced). Let us look at some statistical measures of central tendency, location and dispersion to help us characterize better our sample on Table 2.

Table 2 - Sample characterization of bank specific variables

	Q1	Q2	Q3	P1	P2	P3	TC	PBT	E	A
Panel A: measures of central tendency										
Mean	62 276	49 227	83 389	0.0536	1.3719	0.0163	6 009	781	7 362	137 636
Median	5 797	2 126	6 328	0.0468	0.7776	0.0132	686	127	853	9 214
Panel B: measures of location										
Min	28	6	57	0.0072	0.0003	0.0000	7	-77 307	-7 985	69
Q1	1 486	796	1 999	0.0295	0.4833	0.0086	262	27	259	2 980
Q2	5 797	2 126	6 328	0.0468	0.7776	0.0132	686	127	853	9 214
Q3	29 672	12 754	32 677	0.0660	1.4251	0.0193	2 643	542	3 410	45 601
Max	1 448 638	1 483 870	2 406 555	0.5126	36.5448	0.0811	162 506	20 751	191 215	3 850 024
Panel C: measures of dispersion										
Range	1 448 610	1 483 864	2 406 498	0.5054	36.5445	0.0811	162 499	98 059	199 200	3 849 955
Inter-quartile range	28 186	11 957	30 678	0.0366	0.9418	0.0107	2 381	515	3 151	42 621
Standard deviation	171 180	166 233	246 754	0.0401	2.3002	0.0114	16 069	3 981	21 282	432 951
Coefficient of variation	2.75	3.38	2.96	0.75	1.68	0.70	2.67	5.10	2.89	3.15

Notes:
Q1: Total loans; Q2: Other earning assets; Q3: Total deposits; P1: Cost of borrowed funds (Interest expense/ Total deposits + Long-term debt);
P2: Cost of physical capital (General and administrative expense/ Net fixed assets); P3: Cost of labor (Salaries/ Total assets);
TC: Total cost (interest, non-interest); PBT: Profit before taxes; E: Total equity; A: Total assets.
Q1, Q2, Q3, TC, PBT, E, A in $ millions expressed in real 2009 terms.

Whatever the variable peaked, our sample seems to be positively skewed since the median is clearly bellow the sample mean. In what concerns location, 75% of our sample has less than $29.7 billion of loans, while the maximum value of the sample for the same variable exceeds $1.4 trillion. In terms of dispersion, the variable that has a

wider relative dispersion is the profits before taxes, with the coefficient of variation higher than 5. On the opposite side, the bank specific variable with less relative dispersion is the cost of labor with a coefficient of variation of 0.7.

Moving forward to the bank specific ratios that will be used in the efficiency term of the models, in Figure 4 we can see the trend on the ratios loan to deposits and equity to total assets. In the time frame 2004-2012, the observable trend on both variables is moving towards less leverage: on average, there has been more equity financing banks' activities – from circa 8.4% on 2005, ETA was almost 9.5% on 2012; the transformation ratio of deposits into loans is also decreasing – from 92.8% on 2004, LTD reached 79.3% in 2012.

Figure 4 - Sample mean values by year | LTD and ETA
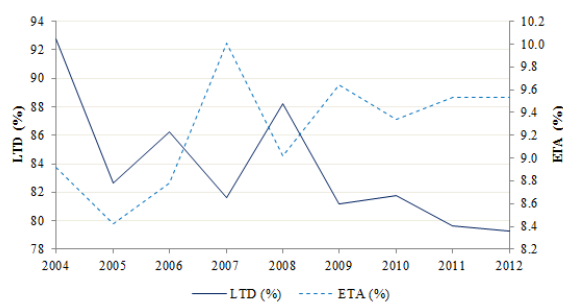
Table 3 has the average values of the bank specific ratios by year and geographical region. On Panel B it is clear that the banks in our sample with higher leverage are in Advanced Economies: ETA 5.42% for Euro Area and 6.5% for Other Advanced Economies; LTD exceeding 101% for both. It is also in these two regions where, on average, the assets under management were less profitable: -0.05% on Euro Area and 0.6% on other Advanced Economies while the sample mean was 1.06%.

Table 3 - Sample means of bank specific ratios

	ROA (%)	LTD (%)	LLT (%)	ETA (%)	CTI (%)
Panel A: means by year					
2004	1.38	92.78	4.54	8.92	59.81
2005	1.03	82.65	4.30	8.42	81.54
2006	1.57	86.21	3.62	8.78	57.51
2007	1.35	81.59	3.68	10.01	60.86
2008	1.02	88.23	3.39	9.02	68.54
2009	0.96	81.20	4.43	9.64	64.98
2010	0.92	81.76	4.87	9.34	65.53
2011	0.57	79.65	4.77	9.53	67.64
2012	1.10	79.28	4.43	9.54	65.49
Panel B: means by location					
EUROAREA	-0.05	101.22	3.30	5.42	66.28
OTHERADVC	0.60	101.93	1.83	6.50	58.05
DEVELASIA	1.33	70.02	3.38	10.69	66.91
LATINA&C	1.95	83.09	4.12	11.91	61.68
MEA	1.02	65.47	7.88	9.85	76.24
EASTEURO	0.97	88.38	7.20	10.29	52.96
TOTAL	1.06	83.00	4.24	9.32	65.69

Notes:
ROA: Return on assets; LTD: Percentage of loans to total deposits; LLT: Percentage of loan losses to total loans;
ETA: Percentage of equity book value to total assets; CTI: Cost-to-income or efficiency ratio.
Sample means have been calculated using bank year observations (865) and not country observations (30)
In assigning countries in regions it was followed the IMF Country classification - WEO Groups and Aggregates Information

3.2.2. Major regulation trends and how it impacts the explanatory variables selection

This thesis tries to find out if there is empirical evidence that regulation on capital requirements affects banks' efficiency. However, due to the negative externalities that the financial sector has on the rest of the economy – something already addressed previously in the literature review –, the regulatory framework does not comprise only capital requirements, but also several other aspects. According to Barth, Caprio and Levine (2012), there was a decrease on the toughness of the restrictions on banks activities until 2006, something that started reversing more recently. In what concerns the remaining three regulatory variables, Barth, Caprio and Levine (2012) concluded that "many more countries were increasing capital requirements over the entire period, whereas there is no marked difference in the increase or decrease of supervisory powers and slightly fewer countries increasing private monitoring compared with those decreasing it". Let us now move on to our sample and understand how the regulatory variables are spread over the different regions using Table 4.

Table 4 - Sample means of regulatory variables by location

	CAPTRQR	OFFDPWR	MKTDISC	ACTRSTR
EUROAREA	4.65	9.12	5.40	1.99
OTHERADVC	4.27	8.38	5.43	1.28
DEVELASIA	5.79	11.00	5.79	2.81
LATINA&C	4.42	10.54	5.66	2.30
MEA	5.01	10.89	7.69	2.74
EASTEURO	4.46	7.92	4.54	2.63
TOTAL	4.89	10.13	5.90	2.34

Notes:
CAPTRQR: Index of capital requirements, accounting for both initial and overall capital stringency (0-6);
OFFDPWR: Measure of the power of the supervisory agencies (0-12);
MKTDISC: Index of market discipline or private monitoring (0-8);
ACTRSTR: Level of restrictions on banks' activities (0-4).
Sample means have been calculated using bank year observations (865) and not country observations (30).
In assigning countries in regions it was followed the IMF Country classification - WEO Groups and Aggregates Information

Countries from Developing Asia are among those with higher scores in the regulatory variables, excluding the market discipline index where the region has only the third highest score. The restrictions on bank activities tend to be lower on Advanced Economies, while the powers of the supervisory authorities tend to be lower in countries from Eastern and Central Europe. Finally, regulation on capital requirements tends to be lower on Other Advanced Economies (excluding countries from Euro Area), while Developing Asia and Middle East and African countries have, on average, stringent capital requirements.

3.2.3. Macroeconomic, financial development and market structure variables

When studying the impact of capital regulations on banks' efficiency, besides controlling for other forms of regulation on the banking sector and for bank specific ratios on performance, credit quality, solvency and efficiency, the literature on the subject suggests to control also for macroeconomic conditions, for the maturity of financial development, and for variables that characterize the market structure faced by banks in the countries where they operate as in Fries and Taci (2005), and Pasiouras, Tanna and Zopounidis (2009). We defined different variables to control for these items. Let us briefly look at how these are distributed in our sample. Table 5 aggregates the mean values by geographical region.

Table 5 - Sample means for macroeconomic, financial development and market structure variables by location

Panel A: macroeconomic and financial development variables

	INFLATN	GDPGRCP	DCPSGDP	MKTCGDP
EUROAREA	2.48	0.43	1.44	0.60
OTHERADVC	1.60	1.41	1.75	1.74
DEVELASIA	6.81	5.86	0.29	0.39
LATINA&C	5.49	4.84	0.46	0.64
MEA	10.80	4.37	0.25	0.27
EASTEURO	5.71	3.71	0.48	0.41
TOTAL	5.64	3.70	0.72	0.60

Panel B: market structure variables

	FOREIGN (%)	GOVERN (%)	CONCENT (%)	
EUROAREA	23.07	10.26	76.58	
OTHERADVC	36.32	14.31	74.88	
DEVELASIA	48.01	38.56	44.51	
LATINA&C	39.11	34.17	53.05	
MEA	35.88	18.45	43.46	
EASTEURO	47.04	24.21	44.20	
TOTAL	37.15	25.40	56.36	

Notes:
INFLATN: Inflation, average consumer prices; GDPGRCP: Gross domestic product, constant prices;
DCPSGDP: Ratio of domestic credit to private sector to GDP; MKTCGDP: Ratio of market capitalization
of listed companies to GDP; FOREIGN: Percentage of the number of foreign owned banks to the number of
the total banks in an economy; GOVERN: Percentage of government-owned banks operating in the market;
CONCENT: Assets of three largest commercial banks as a share of total commercial banking assets.
Sample means have been calculated using bank year observations (865) and not country observations (30).
In assigning countries in regions it was followed the IMF Country classification - WEO Groups and Aggregates Information

The Advanced Economies in our sample faced a slower average growth rate, while also experiencing lower inflation. Concerning financial development variables, Middle East and African Economies have the lowest scores, while the Advanced Economies (excluding the Euro Area) have the higher ratios for domestic credit to private sector (% GDP) – 1.75 – and for market capitalization of listed countries (% GDP) – 1.74. Regarding the market structure variables, our sample suggests that Advanced Economies have a higher degree of market concentration with circa 75%-77% of total commercial banking assets being managed by the market three largest banks. Economies from Developing Asia are those with a higher percentage of government owned banks and foreign owned banks in the sample with 38.6% and 48%, respectively. On the opposite side, the Euro Area has the smaller percentage of government owned banks – 10.3% – and foreign owned banks operating in the market – 23.1%.

3.3. Limitations

The measurement of banks' efficiency varies substantially across the literature due to data sources, as well as the efficiency concepts measured (Berger and Mester, 1997). As aforementioned, we opt for applying the cost concept and the alternative profit concept to assess banks' efficiency. The later was applied due to several constrains in our sample, as explained by Maudos et al. (2002), and Pasiouras, Tanna and Zopounidis (2009). But by doing so, we have not applied a more accepted economic goal which is profit maximization, a superior efficiency concept (Berger and Mester, 1997). The main

advantage of the profit concept is that efficiency is measured against the "best practice point of profit maximization within the dataset" (Berger and Mester, 1997), while both cost and alternative profit concepts hold output fixed regardless of being an optimum point or not. Concerning the estimation technique, the stochastic frontier captures the observed best practice, not necessarily the best possible performance (Hughes and Mester, 2008). So, here the efficiency is always measured against the more efficient observation in the sample, not against an optimal theoretical point. However, the usage of the stochastic frontier – a parametric method – corresponds well with the efficiency concepts – cost and alternative profit – outlined above (Berger and Mester, 1997) and focuses on economic optimization – as opposed to technological optimization.

Regarding the functional form chosen for the stochastic frontiers, we use the translog, which is commonly applied in the literature (Dietsch and Lozano-Vivas, 2000; Fries and Taci, 2005; Pasiouras, Tanna and Zopounidis, 2009). However, the translog function "does not necessarily fit well data that are far from the mean in terms of output size or mix" (Berger and Mester, 1997). To lighten these less favorable characteristics, some flexibility may be added to the translog function. This objective could be achieved with Fourier trigonometric terms (Berger and Mester, 1997).

For the countries that participate in both surveys on regulation – 2007 and 2011 – and for which it was also possible to get all the necessary country specific variables, it was made an effort on mapping and standardizing the answers collected in 2007 and 2011 surveys to allow comparisons and construct consistent variables over time. Due to the 9 year time span that we wish to obtain, many countries were lost because we were not able to gather country specific variables to all of them. After this stage, we end up with 65 countries. In what concerns the bank specific variables used as inputs and outputs in the efficiency frontier, there was a trade-off between the chosen specification and data availability from Bloomberg. Initially, we chose to create a dataset as comprehensive as possible. Since data available on Bloomberg often exclude differentiation for non-financial costs between labor cost and general and administrative expenses, we also worked with an empirical specification that included only two input prices – cost of borrowed funds (P1) and non-financial costs (P2). A similar approach was also followed by Fries and Taci (2005) and the motivation was the same: lack of available data. This approach allows us to get a dataset with 1005 cross-sections from 53 different countries, totalizing 7384 bank-year observations. Nevertheless, besides differences in cross-

sections, countries and variables specification, the broader dataset has higher dispersion. This characteristic impacts the performance and the results obtained with the translog function as claimed by Berger and Mester (1997) and Berger and Humphrey (1997).

Other topic that usually is a matter of debate in the literature on banking efficiency is the role of deposits in the models. On this topic, the approach followed in this study was the value added approach which "considers all liability and asset categories to have some output characteristics rather than distinguishing inputs from outputs in a mutually exclusive way" (Berger and Humphrey, 1992). According to Berger and Humphrey (1992), this controversy on deposits is a consequence of banks' services not being explicitly priced. Because of regulation or institutional reasons, banks pay below market interest rates and do not charge explicit fees on deposits services. If the opposite happened, i.e., if banks paid market interest rates and charged explicit fees on deposits, "then this large explicit revenue flow would be convincing evidence that deposits provide substantial service output" (Berger and Humphrey, 1992). Therefore, to assess if the value added approach on variable definition could have impacts on the tendency showed by our research results, we have also replicated the cost and the alternative profit frontiers but excluding deposits from output variables. With such specification, capital regulation is not statistically different from zero as a determinant of inefficiency either on cost or profit frontiers for our sample.

Finally, it has been a matter of concern on efficiency analysis how to incorporate banks' capital structure, due to its impact on banks' risk taking and, consequently on banks' returns (Hughes and Mester, 2008). Although this dimension has been included in our study, the chosen capital structure may have the objective of maximizing management utility and not bank value. Hughes and Mester (2008) highlight that efficiency structural models start including variables related to bank governance and ownership structure as in Hughes, Mester and Moon (2001). Poor management quality has been identified as one of the main reasons for bank failure (Berger and Humphrey, 1997). Regarding governance, the cost and alternative profit models applied in our study will assume little agency problems between managers and owners. Both stakeholders – management and equity holders – aim to maximize the value of the company (Hughes, Mester and Moon, 2001).

Chapter 4 | Results

4.1. Efficiency scores

After determining the efficiency frontiers for both cost and alternative profit models, the mean efficiency scores for our sample are summarized in Table 6: Panel A with the scores by year; Panel B with efficiency scores by geographical region; Panel C with efficiency means by bank size.

Table 6 - Cost and profit efficiency estimates

	N	Cost efficiency	Profit efficiency
Panel A: means by year			
2004	55	0.8997	0.7545
2005	66	0.9134	0.7528
2006	78	0.9241	0.7780
2007	101	0.9335	0.7776
2008	105	0.9275	0.7121
2009	110	0.9264	0.7766
2010	115	0.9296	0.7707
2011	116	0.9305	0.7490
2012	119	0.9301	0.7655
Panel B: means by geographical region			
EUROAREA	194	0.9391	0.8025
OTHERADVC	74	0.9668	0.8540
DEVELASIA	209	0.9503	0.7423
LATINA&C	226	0.8849	0.6470
MEA	136	0.9169	0.8508
EASTEURO	26	0.9204	0.8177
Panel C: means by size			
[0 - 1 000]	100	0.9298	0.7870
] 1 000 - 2 000]	64	0.8975	0.7196
] 2 000 - 5 000]	142	0.9125	0.7255
] 5 000 - 10 000]	143	0.9184	0.7378
] 10 000 - 20 000]	95	0.9449	0.7627
] 20 000 - 50 000]	111	0.9432	0.7762
] 50 000 - 100 000]	58	0.9051	0.7902
] 100 000 - +∞	152	0.9386	0.7860
TOTAL	865	0.9260	0.7598

Notes:
Cost efficiency: 1/Cost eff. est. (0-1); Profit efficiency: Technical eff. est. (0-1);
Values closer to 1 meaning a higher level of efficiency; Efficiency estimates were obtained from the program FRONTIER (Version 4.1c);
Sample means have been calculated using bank year observations (865) and not country observations (30); In assigning countries in regions it was followed the IMF Country classification - WEO Groups and Aggregates Information;
To group banks by size it was used the variable total assets in $ millions expressed in real 2009 terms.

The sample means cost efficiency score was 0.9260, while sample means alternative profit efficiency was 0.7598. As in Guevara and Maudos (2002), Maudos et al. (2002), and Pasiouras, Tanna and Zopounidis (2009), our results indicate that, on average, banks demonstrate to be more cost efficient than profit efficient when compared with the most efficient bank within the sample data. Over the analysis period, the average efficiency results have not always followed the same pattern (Figure 5). Cost efficiency scores have, on average, improved from 2004 to 2007 and from 2009 to 2011. The year 2007 was, on average, the year with the best cost efficiency estimates from our sample – 0.9335. However, 2012 ended with the third best cost efficiency score – 0.9301 – only bellow 2007 and 2011.

Regarding profit efficiency estimates, they indicate that, on average, banks in our sample improved their profit efficiency in three different time periods: 2005-2006, 2008-2009, and 2011-2012. The year with, on average, the lowest profit efficiency estimate was 2008 – 0.7121 -, while 2006 was the year with the highest profit efficiency estimates: 0.7780.

Figure 5 - Efficiency estimates, 2004-2012
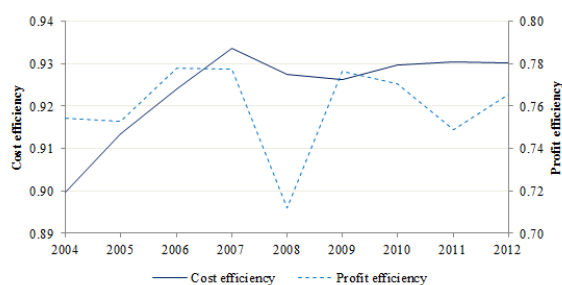
Regarding the efficiency estimates by geographical region, our results show that banks from other Advanced Economies (excluding the Euro Area) are the most cost efficient – 0.9668. On the opposite side, banks from Latin America and Caribbean are simultaneously the least efficient on the cost side and also on the profit side – 0.8849 and 0.6470, respectively. In the remaining geographic regions, over the analysis period, it is possible to observe that banks in the Euro Area are, on average, more cost efficient than banks from Middle East and Africa and East Europe – 0.9391 vs. 0.9169 and 0.9204, respectively. However, both Middle East and Africa banks and East Europe banks have, on average, a better efficiency estimates on profit efficiency than the Euro Area banks – 0.8508 and 0.8177 vs. 0.8025, respectively.

Considering the distribution by size, the most cost efficient banks are, on average, those with balance sheets between $10 and $20 billion, while the most profit efficient are, on average, banks with total assets between $50 and $100 billion. These results are consistent with the literature, – e.g. Berger and Mester (1997); Guevara and Maudos (2002); and Pasiouras, Tanna and Zopounidis (2009) – which suggests that the most efficient banks on the cost side are not necessarily the most profit efficient. To assess if there is correlation within our cost and profit efficiency estimates, as in Pasiouras, Tanna and Zopounidis (2009), we have computed the Pearson coefficient – for linear correlation – and the Spearman coefficient – for non-linear correlation. The coefficients obtained are low: 0.1321 for the Pearson coefficient and 0.0321 for the Spearman coefficient as presented in Table 7. Although low, the Pearson coefficient is statistically

different from zero for a confidence level of 99%. Conversely, the Spearman coefficient is not statistically different from zero for the confidence levels commonly applied. Hence, the correlation does not seem very strong. This might support the claim from Guevara and Maudos (2002) "that the analysis of cost efficiency offers only a partial view of the efficiency of a banking firm and consequently the need to analyze also inefficiencies in profits".

Table 7 - Pearson and Spearman coefficients

	Coefficient	t-ratio
Pearson	0.1321	3.9150 ***
Spearman	0.0321	0.9430

Notes:
*** statistical significance at the 1% level
** statistical significance at the 5% level
* statistical significance at the 10% level

Drilling down the analysis to country level, we find that, on average, the most cost efficient banks are in Cyprus, Denmark, and United Kingdom, with average cost efficiency estimates of 0.9802, 0.9753, and 0.9730, respectively. The least cost efficient banks from our sample operate in Mexico, Morocco, and Nigeria, with average cost efficiency estimates of 0.6981, 0.7468, and 0.7946, respectively. In terms of profit efficiency, those which, on average, had the best efficiency estimates are in Finland, Switzerland, and Denmark – 0.9495, 0.9285, and 0.9246, respectively. On the opposite side, as the least profit efficient, are banks from United States, Brazil, and Portugal, with estimates of 0.2785, 0.5015, and 0.7151. The efficiency estimates by country can be found in the Appendix IV. Having the cost and profit efficiency estimates, let us move forward and analyze how efficiency estimates were influenced by regulation on capital requirements, controlling for other possible determinants of inefficiency considered in the study.

4.2. Determinants of inefficiency

Table 8 presents the results obtained for the country specific determinants of inefficiency. Besides the coefficients for the capital requirements variable and remaining control variables – other regulatory, macroeconomic, and market structure variables – for both cost and profit efficiency models, Table 8 presents also the correspondent t-ratio statistic.

Table 8 - Determinants of cost and profit inefficiency | Country specific variables

	Cost inefficiency	t-ratio		Profit inefficiency	t-ratio	
CAPTRQR	-0.1699	-5.9536	***	-0.4109	-5.4643	***
OFFDPWR	0.0236	2.1241	**	0.6479	9.9113	***
MKTDISC	0.0214	0.9690		-1.4783	-9.0587	***
ACTRSTR	-0.2306	-4.4193	***	-1.4891	-10.0910	***
INFLATN	-0.0524	-6.4034	***	0.0363	1.3084	
GDPGRCP	0.0097	2.0440	**	-0.0367	-1.4361	
DCPSGDP	-0.3768	-8.1086	***	0.9283	3.1217	***
MKTCGDP	-0.3579	-5.5536	***	-1.6602	-12.7642	***
FOREIGN (%)	-0.0104	-6.4782	***	0.0627	12.9829	***
GOVERN (%)	-0.0057	-4.0373	***	0.0131	1.3781	
CONCENT (%)	0.0113	6.6941	***	-0.0555	-11.5667	***
DEVELOP	-0.9119	-6.4568	***	-0.5165	-0.9281	

Notes:
CAPTRQR: Index of capital requirements, accounting for both initial and overall capital stringency (0-6);
OFFDPWR: Measure of the power of the supervisory agencies (0-12);
MKTDISC: Index of market discipline or private monitoring (0-8);
ACTRSTR: Level of restrictions on banks' activities (0-4).
INFLATN: Inflation, average consumer prices; GDPGRCP: Gross domestic product, constant prices;
DCPSGDP: Ratio of domestic credit to private sector to GDP; MKTCGDP: Ratio of market capitalization
of listed companies to GDP; FOREIGN: Percentage of the number of foreign owned banks to the number of
the total banks in an economy; GOVERN: Percentage of government-owned banks operating in the market;
CONCENT: Assets of three largest commercial banks as a share of total commercial banking assets;
DEVELOP: Dummy variable that takes the value one for developed countries and zero for developing conutries;
Estimations were obtained from the program FRONTIER (Version 4.1c); Coefficients have been calculated using
bank year observations (865); *** statistical significance at the 1% level; ** statistical significance at the 5% level;
* statistical significance at the 10% level.

Analyzing the CAPTRQR coefficients, it is possible to conclude that for our sample, the variable is statistically different from zero i.e., it does impact banks inefficiency estimates for both cost and profit models. In the cost efficiency model, the CAPTRQR coefficient has a negative sign, which lead us to conclude that, for our sample, it helps banks being more cost efficient with a confidence level of 99%. As claimed by Pasiouras, Tanna and Zopounidis (2009), this negative effect on cost inefficiency finds support in the literature on two kinds of arguments. If higher regulatory capital requirements induce banks to hold more capital, then it is also expected that less leverage will reduce the expected bankruptcy costs (Berger, 1995; Dietsch and Lozano-Vivas, 2000; Admati et al., 2010) thus reducing the return rate demanded by debt holders. Second, better capitalized banks would have more retained earnings available to fund new investments, since they would have less to pay out in interest payments (Admati et al., 2010). Hence, both claims go towards the argument that regulation on capital requirements might reduce banks' inefficiency.

Regarding the profit efficiency model, the variable CAPTRQR positively affects banks' efficiency, since the coefficient has also a negative sign. Therefore, an increase in the capital requirements for banks in our sample will increase banks profit efficiency estimates, with a confidence level of 90%. Beltratti and Stulz (2009) conducted an analysis the banking performance during the 2007-2008 crisis. The authors concluded that better capitalized banks performed better because equity acts as a buffer to absorb losses. Our analysis covers the 2007-2008 period, where profit efficiency may be

positively influenced by stringent capital requirements as pointed out by Beltratti and Stulz (2009). Overall, for the banks studied in our sample, regulatory capital requirements help to improve banks cost and profit efficiency.

In what concerns the control variables, let us start analyzing the impact of the other three regulatory variables included in the model as determinants of inefficiency. The regulatory variable OFFDPWR is statistically different from zero in the cost model with statistical significance at the 5% level, meaning that it has negative impact on cost efficiency for banks in our sample. Regarding the profit efficiency side, this variable is statistically significant for our sample with a confidence level of 99%. The results indicate that OFFDPWR has a positive impact on our sample profit inefficiency, meaning that the greater the official disciplinary power the less profit efficient the banks in our sample will be. Barth et al. (2002) found evidence that the power of banks supervisors may be associated with higher ratios of nonperforming loans. The authors also found that duplication of banks oversight may tend to increase overhead costs. Additionally, supervision and regulation, in a context where there is a deposit insurance scheme, may aim to reduce excessive risk-taking by banks using mechanisms that probably reduce bank value (Caprio, Laeven, Levine, 2003). Also in the same line of thought, Barth, Caprio and Levine (2004) found a negative relation between prompt corrective power and bank development (even though the authors did not found any relation between official supervision and several indicators of bank performance). Hence, for our sample, the results also to go towards the rationale that due to the impact on banks' costs and optimal risk-taking, increasing the power of disciplinary agencies seem to negatively impact banks' efficiency, either from a cost perspective or from profit perspective.

Regarding the variable MKTDISC, we did not find it statistically significant for cost inefficiencies on banks in our sample. However, the variable is statistically significant in the profit model with a confidence level of 99% and we found that, for our sample, banks which operate in economic environments with higher market discipline or private monitoring turn to be more profit efficient. Creating incentives to increase market discipline is commonly recognized by economists to "exert particularly beneficial effect on the integrity of bank lending in countries with sound legal institutions" (Barth, Caprio and Levine, 2004). Similar impacts of MKTDISC on profit efficiency have also been found by Pasiouras, Tanna and Zopounidis (2009). Therefore, for our sample,

private monitoring seems to have no impact on banks cost efficiency but it has positive impact on profit efficiency.

Finally, moving to the last regulatory variable, ACTRSTR, which represents the level of restrictions on banks' activities, influences negatively both cost inefficiency and profit inefficiency for our sample with a confidence level of 99%. Therefore, we can conclude that for banks in our sample, the higher the restriction on their activities the more efficient banks will be. Applying restrictions on banking activities is a matter of debate and existing literature provide mixed results (Barth, Caprio and Levine, 2004). However, many arguments go towards the benefits of restricting banking activities – e.g. conflict of interests engaging securities underwriting and real estate investment; riskier behavior as the bank may invest in a more broad set of activities; formation of large and complex entities, difficult to manage efficiently; and large financial conglomerates may reduce competition and hence the efficiency of the financial sector (Barth, Caprio and Levine, 2004). Our results seem to be aligned with such theories claiming that restricting banks activities may prevent banks to engage in non-traditional business and hurt profitability because banks may not be able to take advantage of new and more profitable business segments. Additionally, higher restrictions may contribute to banks acquire greater expertise and specialization in specific market segments (Pasiouras, Tanna and Zopounidis, 2009), leading to efficiency gains as well.

Overall, even though the positive impact of the power of the supervisory agencies on both cost and profit inefficiency of banks, the remaining two regulatory control variables - market discipline and restriction on banks' activities - have a positive effect on profit efficiency estimates of banks in our sample. Restricting banks' activities seems to have a positive role on cost efficiency estimates as well. It was not found statistical evidence that market discipline impacts cost efficiency of banks in our study.

Moving forward to the analysis of the macroeconomic control variables, INFLATN, i.e. average consumer prices, is statistically significant on cost efficiency model for banks in our sample, whereas it has no statistically significant impact on profit efficiency estimates. Literature on the subject usually supports the rationale that an increase in the rate of inflation would make the financial sector allocate resources less efficiently, due to informational frictions, but also emphasizes that such impact is only binding when inflation exceeds certain critical rates (Boyd, Levine and Smith, 2001). Grigorian and

Manole (2002), in a study on banking sector in transition economies, did not find evidence of the impact of inflation with large-scale inefficiencies, either in the form of price – interest rate margins – or non-price – excessive branching. Regarding changes in real GDP – GDPGRCP –, we find positive significant impact, at the 5% level, on cost inefficiency for our sample. According to Pasiouras, Tanna and Zopounidis (2009), banks may have less caution on controlling costs when they face output expansion. In what concerns GDPGRCP impact on profit efficiency estimates, our study did not find statistically significant impact for banks in our sample.

Looking into the coefficients obtained for the financial development control variables, we found that domestic credit to private sector – DCPSGDP – has a negative impact on cost inefficiency, statistically significant at 1% level for our sample. Similar results were found by Pasiouras, Tanna and Zopounidis (2009). Conversely, the impact on profit inefficiency is, on average, positive for our sample, also with a confidence level of 99%. As the banking sector increases in size, new entrances are attracted to the market, increasing competition. Therefore, banks in our sample may have the incentive to be more cost efficient, as new entrants put additional pressure on margins and revenues, which in turn results in lower profit efficiency (Demirgüç-Kunt and Huizinga, 2000). In what concerns the size of the equity market as a percentage of GDP, MKTCGDP, it impacts negatively both cost and profit inefficiency for banks in our sample with a confidence level of 99%. This outcome is in line with Demirgüç-Kunt, Laeven and Levine (2004) for whom a better developed stock market may create a competitive environment, putting pressure on how banks operate and turning them more efficient. Demirgüç-Kunt and Huizinga (2000) sustain also that as financial and stock markets develop, there is more available information helping banks to monitor borrowers leading to improved cost-efficiency. With better information on their potential borrowers and prospect clients, banks can also make a better fit of their product portfolio, potentially increasing revenues and profits. The positive impact of developed capital markets on banks' soundness is also sustained by Dima, Dincă and Spulbăr (2014). Generally, the results obtained from our sample corroborate such claims.

In what concerns the other environmental control variables, the percentage of foreign owned banks in an economy, identified as FOREIGN, is statistically significant at the 1% level on both cost and profit efficiency models. The results in our sample

demonstrate that increasing the percentage of foreign owned banks will impact negatively cost inefficiency and positively on profit inefficiency. There seems to be no consensus in the literature on the impact of foreign owned banks on the efficiency of banking sector. This variable was used for control the degree of openness to competition on banking market, which is expected to impact profitability (Barth et al., 2002). Barth et al. (2002) found evidence that an increase on foreign owned banks leads to an increase of the level of the nonperforming loans. The motive may be that as foreign banks enter in a new market, they try to win new clients, downgrading the standard credit conditions. Therefore, less profit efficiency may be expected. Conversely, in what concerns cost efficiency estimates, our findings seem to be consistent with the positive impact of foreign competition on cost efficiency as in Fries and Taci (2005), and Pasiouras, Tanna and Zopounidis (2009). Grigorian and Manole (2002) claim that foreign owned banks may have access to better risk management and operational techniques leading to better cost efficiency. As already mentioned, competition – in this case of foreign banks – will also be an important incentive to banks manage costs efficiently.

The variable percentage of government-owned banks operating in the economy, GOVERN, is also statistically significant in our sample for the cost efficiency model. We have found a negative effect on cost inefficiency of GOVERN for our sample with a confidence level of 99%. Our results are in line with Pasiouras, Tanna and Zopounidis (2009) and are consistent with the view that state owned banks have a positive role on the soundness of the financial system (Stiglitz, 2004). In what concerns the impact of GOVERN on the profit inefficiency, the coefficient is positive, although not statistically significant.

Regarding the variable CONCENT, meaning the assets of three largest commercial banks as a share of total commercial banking assets, it is statistically significant at the 1% level for the cost model. Our results seem to demonstrate that, on average, the higher concentration level in the banking sector, the less cost efficient banks will be. Depending on what was the cause of an higher concentration on banking market, the impact on cost efficiency could go either way: if the driver for concentration was market power, inefficiency in costs may rise; if the objective was consolidate the market with the most efficient banks in the market, then the result may be an increase in cost efficiency (Fries and Taci, 2005; Kasman and Yildirim, 2006). Our results seem to go

with the former view. Conversely, the impact of CONCENT on the profit inefficiency is negative with a confidence level of 99%, meaning that higher concentration of banks operating in an economy will lead to better profit efficiency estimates for banks in our sample. According to Berger and Mester (1997), banks with higher market power are able to charge higher prices, generating additional returns. The results obtained seem to support the market power theory and are somehow consistent with what we also found on the cost side.

Finally, the dummy variable DEVELOP, which aims to find out if operating in a developed economy affects efficiency, impacts negatively both cost and profit inefficiency, although only on the cost model the variable is statistically significant at the 1% level. These results are in line with the fact that banks operating in advanced economies are managed in an institutional environment that induces efficiency. Additionally, banks also have access to higher educated labor force and to state-of-the-art technology (Pasiouras, Tanna and Zopounidis, 2009).

In the inefficient component of our models, besides the country specific variables, we also considered bank specific control variables. The results for these determinants of cost and profit inefficiency are presented in Table 9.

Table 9 - Determinants of cost and profit inefficiency | Bank specific variables

	Cost inefficiency	t-ratio	Profit inefficiency	t-ratio
ROA (%)	-0.0134	-1.8869 *	-0.0459	-1.2857
LTD (%)	0.0035	8.4402 ***	0.0104	7.5072 ***
LLT (%)	0.0132	4.0719 ***	0.0385	2.9657 ***
ETA (%)	-0.0022	-0.8043	-0.0378	-2.1509 **
CTI (%)	0.0019	5.6475 ***	0.0055	5.2905 ***

Notes:
ROA: Return on assets; LTD: Net loans to deposit and borrowing; LLT: Loan loss reserve to gross loans;
ETA: Equity to total assets; CTI: Cost to income.
Estimations were obtained from the program FRONTIER (Version 4.1c); Coefficients have been calculated using
bank year observations (865); *** statistical significance at the 1% level; ** statistical significance at the 5% level;
* statistical significance at the 10% level.

From the selected variables, the ratio of equity to total assets, ETA, negatively impacts inefficiency for our sample on both cost and profit models. However, ETA is only statistically significant on the profit efficiency model at the 5% level. This result means that ETA ratio does not affect cost inefficiency of banks in our study, while it negatively impacts profit inefficiency. Such result, combined with the coefficients obtained for the capital requirement variable, is interesting, since bankers usually argue that equity is an inefficient way of funding their business (Admati et al., 2010). The variable cost to income, CTI, affects positively banks' inefficiency in our sample. The

cost to income or efficiency ratio can, as suggested, be understood as a measure of efficiency (Berger and Mester, 1997; Barth, Caprio and Levine, 2004; Bonfim and Kim, 2014). As such, the result is in line with what was expected: the higher the cost to income ratio, the less cost efficient banks in our sample are expected to be with a 99% confidence level. The same happens with profit efficiency: the higher the cost to income ratio, the less profit efficiency banks are expected to be. Regarding the variable loan loss reserves, LLT, the results are statistically significant at the 1% level and are consistent with the expected, i.e., LLT positively affects banks' efficiency. Therefore, the higher the percentage of loan losses, the least efficient a bank in our sample will be. Concerning the variable net loans to deposits, LTD, the results suggest that it affects positively both cost and profit inefficiency of banks in our sample, i.e., the higher the ratio loan to deposits, the less efficient a bank will be. The results are statistically significant at the 1% level. As banks have an implicit public guarantee over deposits, they tend to pay less for this kind of funding than the opportunity cost of funds (Berger and Humphrey, 1992). Therefore, as banks use other kind of funding to finance their loans or concede more loans than their deposits portfolio would be able to fund efficiently, the efficiency estimates for banks in our sample will be worse. Finally, the variable return on assets – ROA – negatively impacts cost and profit inefficiency but it is only statistically significant on cost efficiency frontier at the 10% level. For our sample, the higher the bank return on assets, the more cost efficient it is expected to be.

After analyzing the statistical significance of the coefficient effects individually, it is also important to analyze globally how banks inefficiency in our sample is explained by the selected variables. According to Battese and Coelli (1995) the variance parameter, gamma, is a good measure of how the inefficiency effects are likely to be highly significant in the analysis of the stochastic frontier dependent variable. Table 10 presents the estimated variance parameters for both cost and profit efficiency models.

Table 10 - Estimated variance parameters

	Cost efficiency		Profit efficiency	
	Coefficient	Standard-error	Coefficient	Standard-error
Sigma-squared	0.0586	0.0090	1.3291	0.1701
Gamma	0.9457	0.0111	0.9737	0.0048

Notes:
Estimations were obtained from the program FRONTIER (Version 4.1c).

The gamma estimates are very close to one for both models. We can conclude that the inefficiency effects are likely to be highly significant in the analysis of cost efficiency – gamma coefficient is 0.9457 –, and in the analysis of profit efficiency – gamma coefficient is 0.9737.

Also important for the analysis of the efficiency frontiers globally is to test if all inefficiency coefficients are different from zero, i.e., the absence of inefficiency effects in the frontiers ($H_0: \gamma = \delta_0 = \delta_1 = \cdots = \delta_{17}$). A likelihood-ratio test (LR test) was used to test this hypothesis:

$$\lambda = -2\{log[L(H_0)] - log[L(H_1)]\} \tag{10}$$

where the $log[L(H_0)]$ and $log[L(H_1)]$ are obtained from the maximized values of the log-likelihood function under the null hypothesis (H_0) and the alternative hypothesis (H_1) respectively. The LR test statistic has a "mixed" chi-square distribution (Kodde & Palm, 1986; Coelli, 1996). The null hypothesis is strongly rejected at the 5% level of significance for the cost efficiency model and also for the profit efficiency model. LR tests and critical values are presented in Table 11. Therefore, we can conclude that the inefficiency effects exist for banks in our sample, impacting both banks' total costs and banks' profits before taxes.

Table 11 - Empirical results for the hypothesis tests of the inefficiency effects

Null hypothesis	Cost efficiency		Profit efficiency		Decision
	LR test	Critical value	LR test	Critical value	
$H_0: \gamma = \delta_0 = \delta_1 = \cdots = \delta_{17}$	414.46	29.55	665.70	29.55	Reject H_0

Notes:
Estimations fore LR test were obtained from the program FRONTIER (Version 4.1c); Critical values for the test statistics have a "mixed" chi-square distribution (Kodde & Palm 1986) with 19 degrees of freedom and a statistical significance at the 5% level.

4.3. Discussion

"For most bankers there is an uneasy tension between making banks safer and making them attractive investments" (The Economist, 2013b). However, the results obtained for our sample seem to support the idea that capital regulation does not have to push banks to operate on a less efficient way. The results hold both from a cost efficiency perspective, and from a profit efficiency perspective.

Notwithstanding these results, we think it is important, from a robustness perspective, to briefly describe how we got to this final specification and the intermediate results we obtained during the process. Thus, we have tried several other variables definitions and

model specifications. Our first approach considered only two input prices, defined as financial costs and non-financial costs. This approach has been also applied by Fries and Taci (2005) and Kasman and Yildirim (2006) due to lack of data availability on employee costs and other overhead costs, which was exactly the same motive that led us in the same path. By doing so, we would get a significant increase on the number of countries studied and also on the number of bank-year observations. However, with such variables specification, we were not able to obtain estimates for the inefficiency parameters of the cost efficiency model. Since we were trying to get a comprehensive view on the impact of capital regulation on bank efficiency, studying both cost and profit perspectives was necessary. Therefore, several adjustments to the variable definitions were made in the process, while trying to keep as many observations as we could. One of the approaches followed was normalization of bank specific variables by the country mean value. An alternative approach also followed was to put a cap and a floor on variables values. In this sense, no variable could be less than the percentile 10th or larger than the percentile 90th. We have also tried to normalize bank specific variables for each bank's total assets. All these approaches did not generate results for the cost efficiency model. However, for the profit efficiency frontier, the results for the different samples studied – the number of bank-year observations were changing according to data availability to construct the variables – seemed to converge in a similar finding: regulation on capital requirements negatively affects profit inefficiency, although the estimates were not always statistically significant for the commonly applied confidence levels. However, and we believe that is a relevant result, capital requirements never positively impact profit inefficiency.

Different approaches have also been followed in the sample selection criteria. One of the approaches followed was selecting banks that belong to the same country. The selected country was the USA because it was the country with more bank-year observations. A different sample selection method that was also tested was to construct a balanced panel dataset, i.e., to consider banks for which there was available data for the full nine years of the study. Again, no results were obtained for the cost efficiency frontier. Regarding the impact of capital regulation on profit efficiency, no statistical evidence was found that it would positively affect inefficiency.

Thus, the methodology followed in the study is highly impacted by variable definition. Only by specifying three input prices – borrowed funds, physical capital and labor – it

was possible to generate results for both cost and profit efficiency frontiers. But this approach came with a cost: to sacrifice between three and six thousand bank-year observations, depending on with which specifications we are comparing. However, all the results obtained until then were consistent with the claim that regulation on capital requirements does not affect negatively banking efficiency.

In defining the variable cost of borrowed funds (P1), the approach usually followed is to compute a ratio between interest expenses and deposits. However, besides deposits, banks hold other interest-bearing financial obligations that need to be accounted for if we intend to have an accurate proxy for the variable cost of borrowed funds. Hence, besides deposits and short-term borrowing, also long-term debt was included as denominator in the variable computation. This new specifications led to the final version of the results presented in the study and, as we aforementioned, goes towards the argument that capital requirements regulation does not negatively impact bank efficiency.

Regarding the control variables considered in our study, the impact of the remaining three regulatory variables on our sample efficiency estimates did not keep the same level of robustness when the variable definition changed. Macroeconomic variables were also subject to volatility in results depending on how variables were defined. Financial development variables' positive impact on cost efficiency seems to hold despite variables definition. The same does not happen on profit efficiency. On the other environmental variables, consistency seems also to hold for the cost efficiency model. On profit efficiency, we also find some volatility in the results. Finally, the bank specific variables seem to hold consistency across different specifications, with the variables loan to deposits, loan loss reserve to gross loans, and cost to income positively impacting banks inefficiency in our sample. The variables return on assets and equity to total assets negatively impact profit inefficiency whatever the cost of borrowed funds specification is applied.

Therefore, despite the robustness of our results regarding the impact of capital regulation on banks' efficiency – even though not always statistically significant until a broad liabilities definition was applied –, the methodology followed seems to be very sensitive to variables definition. Our final results were based on variables definitions supported in the literature (Dietsch and Lozano-Vivas, 2000; Maudos et al., 2002;

Pasiouras, Tanna and Zopounidis, 2009) but came at the cost of losing a large number of bank-year observations. Hence, due to the relevance of the matter on public policy, the on-going debate on banking regulation and, consequently, the impact of any decision-making on the economy as a whole, we think it might be useful to continue the research on this topic, mainly in gathering a more comprehensive dataset which would allow a more representative and robust analysis on the matter.

4.4 Capital regulation: does it impact banks' efficiency (revisited)?

In the literature review, we have discussed several theoretical arguments for and against setting higher capital requirements on banking industry. But no matter the line of though one defends, it is when bad times come that the strength of banks capital structure is placed into test. The problem with social sciences is that some theories and models are only tested empirically when the happenings we wish to analyze occur. Hence, being able to analyze how regulation on capital requirements impacted banks' efficiency during the time horizon that sparked one of the biggest financial crisis ever is probably one of the major gains of this thesis for empirical knowledge on this subject. Although the continuous reference to the impact of increasing capital requirements on banks profitability (The Economist, 2014c), ours results suggest that capital requirements negatively impacts on banks inefficiency for the time window 2004-2012. However, if we analyze the efficiency estimates between 2004 and 2012, there is a clear drop – especially on profit efficiency estimates – on 2008, which is the year of Lehman Brothers bankruptcy. Cost efficiency estimates continued to drop one year further after bounce back. But both cost and profit efficiencies estimates did not continue the same improving trend that, on average, banks in our sample were following between 2004 and 2007. Such findings raised questions regarding the consistency of the coefficients obtained if we split the overall time frame into two periods. Considering the Lehman Brothers bankruptcy year as the relevant date for the splitting, two sub-samples were created: one with bank-year observations between 2004 and 2007; and a second sub-sample with bank-year observations for the time frame 2008-2012[2]. Table 12 presents the results for the determinants of inefficiency in the sample with bank-year observations 2004-2007.

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[2] A third sub-sample containing only bank-year observations between 2009 and 2012 (i.e., excluding 2008 as it was the relevant year for the split) was analyzed. The results on capital requirements coefficients are consistent with what was obtained when we include 2008 in the second sub-sample.

Table 12 - Determinants of cost and profit inefficiency | Bank-year observations 2004-2007

	Cost inefficiency	t-ratio		Profit inefficiency	t-ratio	
CAPTRQR	-0.0895	-3.3323	***	0.0756	0.4384	
OFFDPWR	0.0391	2.6537	***	0.0954	1.6569	*
MKTDISC	-0.0420	-1.5020		-1.1006	-4.9731	***
ACTRSTR	-0.0970	-2.7935	***	-0.9994	-4.0418	***
INFLATN	-0.0348	-3.4517	***	0.0445	0.7774	
GDPGRCP	0.0086	0.6381		0.0225	0.2857	
DCPSGDP	-0.3509	-2.1048	**	1.4644	2.3725	**
MKTCGDP	-0.1139	-1.7575	*	-2.1659	-5.2867	***
FOREIGN (%)	-0.0083	-4.0377	***	0.0002	0.0236	
GOVERN (%)	0.0046	2.2604	**	0.0605	3.6353	***
CONCENT (%)	0.0033	1.4893		0.0278	2.1276	**
DEVELOP	-0.2364	-1.7391	*	-2.5222	-3.0190	***

Notes:
CAPTRQR: Index of capital requirements, accounting for both initial and overall capital stringency (0-6);
OFFDPWR: Measure of the power of the supervisory agencies (0-12);
MKTDISC: Index of market discipline or private monitoring (0-8);
ACTRSTR: Level of restrictions on banks' activities (0-4).
INFLATN: Inflation, average consumer prices; GDPGRCP: Gross domestic product, constant prices;
DCPSGDP: Ratio of domestic credit to private sector to GDP; MKTCGDP: Ratio of market capitalization
of listed companies to GDP; FOREIGN: Percentage of the number of foreign owned banks to the number of
the total banks in an economy; GOVERN: Percentage of government-owned banks operating in the market;
CONCENT: Assets of three largest commercial banks as a share of total commercial banking assets;
DEVELOP: Dummy variable that takes the value one for developed countries and zero for developing conutries;
Estimations were obtained from the program FRONTIER (Version 4.1c); Coefficients have been calculated using
bank year observations (300); *** statistical significance at the 1% level; ** statistical significance at the 5% level;
* statistical significance at the 10% level.

On the cost efficiency model, the variable capital requirements – CAPTRQR – impacts negatively banks inefficiency for the sub-sample 2004-2007. This result is consistent with the coefficient obtained for the complete sample. The impacts of the remaining three regulatory control variables on cost inefficiency for the sub-sample 2004-2007 are also consistent with what we have found for the 2004-2012 time window. But on the profit efficiency model, the capital requirement coefficient is, for the sub-sample 2004-2007, positive, even though not statistically significant. No changes on the impact of the remaining regulatory variables were found.

Let us now get an overview on the results obtained on the sub-sample 2008-2012 (Table 13).

	Cost inefficiency	t-ratio		Profit inefficiency	t-ratio	
CAPTRQR	-0.1912	-4.8617	***	-0.9045	-8.7307	***
OFFDPWR	-0.0966	-3.1713	***	0.0640	0.8919	
MKTDISC	0.0799	3.0030	***	-0.6312	-3.4730	***
ACTRSTR	-0.3252	-2.9472	***	-3.3010	-18.5286	***
INFLATN	-0.0736	-6.5011	***	-0.3453	-8.6282	***
GDPGRCP	0.0077	1.3462		0.0473	1.4982	
DCPSGDP	0.1193	1.1625		0.6465	1.4800	
MKTCGDP	-0.5044	-7.0349	***	-3.7495	-13.6623	***
FOREIGN (%)	-0.0050	-3.2705	***	0.0655	9.1553	***
GOVERN (%)	-0.0166	-4.3547	***	-0.0270	-2.9036	***
CONCENT (%)	0.0200	6.8205	***	-0.0545	-5.9402	***
DEVELOP	-1.9906	-4.6160	***	-3.3223	-5.2550	***

Notes:
CAPTRQR: Index of capital requirements, accounting for both initial and overall capital stringency (0-6);
OFFDPWR: Measure of the power of the supervisory agencies (0-12);
MKTDISC: Index of market discipline or private monitoring (0-8);
ACTRSTR: Level of restrictions on banks' activities (0-4).
INFLATN: Inflation, average consumer prices; GDPGRCP: Gross domestic product, constant prices;
DCPSGDP: Ratio of domestic credit to private sector to GDP; MKTCGDP: Ratio of market capitalization
of listed companies to GDP; FOREIGN: Percentage of the number of foreign owned banks to the number of
the total banks in an economy; GOVERN: Percentage of government-owned banks operating in the market;
CONCENT: Assets of three largest commercial banks as a share of total commercial banking assets;
DEVELOP: Dummy variable that takes the value one for developed countries and zero for developing conutries;
Estimations were obtained from the program FRONTIER (Version 4.1c); Coefficients have been calculated using
bank year observations (565); *** statistical significance at the 1% level; ** statistical significance at the 5% level;
* statistical significance at the 10% level.

The impacts on banking inefficiency of regulatory capital requirements are statistically significant and negative on both cost and profit models. This is consistent with the overall results when we use 2004-2012 bank-year observations. The variable OFFDPWR – measure of the power of supervision – has a negative impact on banks inefficiency for this sub-sample, while market discipline index – MKTDISC – is statistically significant and has a positive impact on cost inefficiency. On the cost model, the impact of these two variables has changed when comparing this sub-sample with the full sample. On the profit efficiency side, the results are aligned with what was obtained for the full sample – even though OFFDPW is no longer statistically significant. Hence, overall, the impact of capital requirements on cost efficiency frontiers in the two sub-samples seems to be consistent with what was found using data from the 9 years' time-horizon. Regarding the profit efficiency model, capital requirements is also statistically significant for the sub-period 2008-2012 and negatively affects profit inefficiency. However, for the period before 2008, the capital regulation coefficient positively impacts profit inefficiency, even though not being statistically significant. From a public policy perspective, this finding is particularly relevant because it seems that in the years in which banks faced stressful conditions, capital requirements start to positively impact banks' profit efficiency. That is exactly the reason why capital is important: to absorb losses when banks incur on them without interfering with banks' role as financial intermediaries (Berger, Herring and Szegö, 1995). And, as our results demonstrate, it seems that capital requirements importance

for banks' efficiency is highlighted during stressful economic conditions, something that is in line Admati et al. (2010) claim that "capital regulation can be a powerful tool for enhancing the role of banks in the economy".

Chapter 5 | Conclusion

The impact of imposing minimum capital requirements on banks is a controversial subject, with the industry arguing that there is a tradeoff between the equity level a bank must have and the industry profitability. However, this rule of thumb has been challenged theoretically (Admati et al., 2010) and empirically. For instance, after Sweden's 1990 banking crisis, the country took the lead on regulation, imposing some of the highest capital ratios in the rich world (The Economist, 2013b). Despite that, "Swedish banks are generating the highest returns on equity among rich-world banks" (The Economist, 2013b). Several reasons are pointed out for this outcome and comprise cost control, market structure, and solidity of their balance-sheets due to… high capital ratios.

To study banks' activities, instead of using traditional measures of performance (e.g. return on equity), our approach applied efficiency measures which, according to Berger and Humphrey (1997), are "particularly valuable in assessing and informing government policy regarding financial institutions". Therefore, this study evaluated how regulation on capital requirements impacts cost and profit efficiency of banks. It allowed an international comparison on banking regulation, capturing changes on public policies towards banks over time and encompassed one of the major financial crisis since 1929. It used a panel dataset of 865 observations from 156 publicly listed commercial banks operating in 30 countries and covering a nine year time-horizon (2004-2012). For doing so, as Berger and Humphrey (1992), Berger and Mester (1997), Dietsch and Lozano-Vivas (2000), Maudos et al. (2002), and Pasiouras, Tanna and Zopounidis (2009), we have followed a structural approach to explain banks' performance. We modelled a cost efficiency frontier and an alternative profit efficiency frontier. Cost efficiency analysis has been an important potential source of cost reduction (Maudos et al., 2002). However, minimizing costs is not a sufficient condition to achieve profit efficiency. Hence, it was modelled an alternative profit frontier to evaluate the impact of capital regulation on this dimension as well. Maudos et al. (2002) and Kasman and Yildirim (2006) pointed out that the alternative profit efficiency is more appropriate when international comparisons are being made, which has been also the case.

The impact of regulatory capital requirements on banking efficiency was assessed using the Battese and Coelli (1995) stochastic frontier production function for panel data to

estimate inefficiency effects. Besides the impact on capital regulation, we also controlled for the influence of other regulatory variables, macroeconomic conditions, market structure characteristics and the state of financial development.

Our results indicate that, on average, banks demonstrate to be more cost efficient than profit efficient. Also consistent with the literature, – e.g. Berger and Mester (1997); Guevara and Maudos (2002); and Pasiouras, Tanna and Zopounidis (2009) –, our results suggest that the most efficient banks on the cost side are not necessarily the most profit efficient. These results go towards the idea "that the analysis of cost efficiency offers only a partial view of the efficiency of a banking firm and consequently the need to analyze also inefficiencies in profits" (Guevara and Maudos, 2002).

Regarding the impact of regulation on capital requirements over banks' efficiency, we concluded that it negatively affects inefficiency, meaning that, for our sample, an increase on regulatory equity ratios will lead to efficiency improvement. Those findings are in the spirit of Berger (1995), Dietsch and Lozano-Vivas (2000), Beltratti and Stulz (2009), and Mehran and Thakor (2011). We have also assessed if there was any change on the impact of capital requirements on banks' efficiency before and after the peak of the financial crisis, dividing the sample in two sub-periods: 2004-2007; and 2008-2012. In what concerns cost efficiency, the impacts of capital requirements are consistent for all the analyzed periods, i.e., it negatively impacts cost inefficiency. However, the same does not happen with profit efficiency model. In the period 2004-2007, the capital regulation coefficient positively impacts profit inefficiency, even though not being statistically significant. From a public policy perspective, which should care about systemic risk, this finding is particularly relevant because as banks faced a worsening of the surrounding conditions, it seems that capital requirements started to positively impact banks profit efficiency. Similar findings were found by Beltratti and Stulz (2009) and are in line with capital relevance as a loss absorber and as a tool of preventing financial distress (Berger, Herring and Szegö, 1995).

Although our main focus is the impact of capital requirements on banks' efficiency, let us also summarize what can be concluded for the remaining regulatory control variables due to its relevancy for public policies. The power of disciplinary agencies seems to negatively impact banks' efficiency, either from a cost perspective or from profit perspective. However, on the cost frontier for the sub-sample 2008-2012, the reverse

seems to be true as well. So, in stressful conditions, it may help banks being more cost efficient. Regarding market discipline, we concluded that banks which operate in economic environments with higher market discipline or private monitoring turn to be more profit efficient. This conclusion also holds if we analyze the dataset separately, i.e., 2004-2007 and 2008-2012. Finally, the level of restrictions on banks' activities negatively impacts inefficiency. Hence, from a public policy perspective, we would say that regulation should aim to increase market discipline, while restricting banks activities. This could result in safer banks, and not necessarily less efficiency in providing financial services.

In bank specific determinants of inefficiency, the variable equity to total assets negatively impacts either profit inefficiency or cost efficiency (although not statistically significant in the later). Such result, combined with the result obtained for the regulatory capital requirements variable, may be interesting in a context where bankers usually argue that equity is an inefficient way of funding their business. Conversely, our results seem to support Admati et al. (2010), for whom "capital regulation can be a powerful tool for enhancing the role of banks in the economy".

As the new regulatory framework that will be applied to banks is still an ongoing process, this thesis addresses "the vexed question of the level of capital banks should hold to guard against future losses" (The Economist, 2014d). Our findings go towards those who sustain that setting higher capital requirements will not only contribute for banks' resilience, but also to increase banks' efficiency as well (Admati et al., 2010; Eavis, 2013). Other regulatory tools may also contribute to the system stability, without harming banks' efficiency. Such results are extremely relevant from a public policy perspective, as it may help to design a better regulatory framework. Despite these results, a more comprehensive study, gathering a broader dataset will definitely be an important step forward to support the decision-making process among banking industry stakeholders. Not least, it would also be important to deepen the knowledge on what does truly impact banks' efficiency, looking at other dimensions, such as corporate governance (Laeven and Levine, 2009), cost control, or market structure. As externalities for the economy of the last financial crisis are not over yet, this is the time to understand how the probability of such events can be reduced in the future. Setting higher minimum capital requirements has been one of the main solutions put forth to

address this problem. Our results show that this does not necessarily imply sacrificing banks' efficiency.

Appendices

Appendix I – Information on regulatory variables

Variable	Category	Description (BRSS 2007)	Description (BRSS 2011)
CAPTRQR	Capital requirements	This variable is calculated adding 1 if the answer is yes to the questions 1-4 and 0 otherwise. Conversely, 1 will be added if answer to questions 5 and 6 is no (and 0 otherwise). 1) Is this ratio risk weighted in line with the 1988 Basle guidelines? 2) Does the minimum ratio vary as a function of market risk? 3) Before minimum capital adequacy is determined, which of the following are deducted from the book value of capital: A. Market value of loan losses not realized in accounting books? B. Unrealized losses in securities portfolios? C. Unrealized foreign exchange losses? If any answer to 3.A, 3.B, or 3.C is yes, then the answer to 3 will be considered as yes and 1 point will be added. 4) Are the sources of funds to be used as capital verified by the regulatory/supervisory authorities? 5) Can the initial disbursement or subsequent injections of capital be done with assets other than cash or government securities? 6) Can initial disbursement of capital be done with borrowed funds?	This variable is calculated adding 1 if the answer is yes to the questions 1-4 and 0 otherwise. Conversely, 1 will be added if answer to questions 5 and 6 is no (and 0 otherwise). 1) Which regulatory capital adequacy regimes did you use as of end of 2010: A. Basel I? B. Basel II? If 1.A or 2.B is answered with yes, then the answer to 1 will be considered as yes and 1 point will be added. 2) Which risks are covered by the current regulatory minimum capital requirements in your jurisdiction: market risk? 3) Are the following items deducted from regulatory capital: unrealized losses in fair valued exposures? 4) Are the sources of funds to be used as capital verified by the regulatory/supervisory authorities? 5) Can the initial disbursement or subsequent injections of capital be done with assets other than cash or government securities? 6) Can initial capital contributions by prospective shareholders be in the form of borrowed funds?
OFFDPWR	Power of the supervisory authorities	This variable is obtained adding 1 if the answer is yes to the following 12 questions (and 0 otherwise). 1) Does the supervisory agency have the right to meet with external auditors to discuss their report without the approval of the bank? 2) Are auditors required by law to communicate directly to the supervisory agency any	This variable is obtained adding 1 if the answer is yes to the following 12 questions (and 0 otherwise). 1) Does the banking supervisor have the right to meet with the external auditors and discuss their report without the approval of the bank? A. No; B. Yes, it happens on a regular basis; C. Yes, it happens on an exceptional basis. One

presumed involvement of bank directors or senior managers in illicit activities, fraud, or insider abuse? 3) Can supervisors take legal action against external auditors for negligence? 4) Can the supervisory authority force a bank to change its internal organizational structure? 5) Are off-balance sheet items disclosed to supervisors? 6) Can the supervisory agency order the bank's directors or management to constitute provisions to cover actual or potential losses? 7) Can the supervisory agency suspend the directors' decision to distribute: A. Dividends? B. Bonuses? If 7.A or 7.B is answered with yes, then the answer to 7 will be considered as yes and 1 point will be added. 8) Can the supervisory agency suspend the directors' decision to distribute management fees? 9) Who can legally declare that a bank is insolvent: bank supervisor? 10) Regarding bank restructuring and reorganization, can the supervisory agency supersede shareholder rights? 11) Regarding bank restructuring and reorganization, can the supervisory agency remove and replace management? 12) Regarding bank restructuring and reorganization, can the supervisory agency remove and replace directors?

point was added either to answer B or C. 2) Are auditors required to communicate directly to the supervisory agency any presumed involvement of bank directors or senior managers in illicit activities, fraud, or insider abuse? 3) In cases where the supervisor identifies that the bank has received an inadequate audit, does the supervisor have the powers to take actions against the external auditor? 4) Can the supervisory authority force a bank to change its internal organizational structure? 5) Do banks disclose to the supervisors off-balance sheet items? 6) Please indicate whether the following enforcement powers are available to the supervisory agency: require banks to constitute provisions to cover actual or potential losses? 7) Please indicate whether the following enforcement powers are available to the supervisory agency: require banks to reduce or suspend dividends to shareholders? 8) Please indicate whether the following enforcement powers are available to the supervisory agency: require banks to reduce or suspend bonuses and other remuneration to bank directors and managers? 9) Does bank supervisor has the powers to declare insolvency? 10) Does bank supervisor has the powers to supersede shareholders' rights? 11) Please indicate whether the following enforcement powers are available to the supervisory agency: suspend or remove managers? 12) Please indicate whether the following enforcement powers are available to the supervisory

			agency: suspend or remove bank directors?
MKTDISC	Market discipline	This variable is determined adding 1 if the answer is yes to the questions 1-6 and 0 otherwise. Conversely, 1 will be added if answer to questions 7 and 8 is no (and 0 otherwise). 1) Is subordinated debt allowable as part of regulatory capital? 2) Are financial institutions required to produce consolidated accounts covering all bank and any non-bank financial subsidiaries (including affiliates of common holding companies)? 3) Are off-balance sheet items disclosed to the public? 4) Must banks disclose their risk management procedures to the public? 5) Are bank directors legally liable if information disclosed is erroneous or misleading? 6) Do regulations require credit ratings for commercial banks? 7) Does accrued, though unpaid, interest/principal enter the income statement while the loan is still non-performing? 8) Is there an explicit deposit insurance protection system?	This variable is determined adding 1 if the answer is yes to the questions 1-6 and 0 otherwise. Conversely, 1 will be added if answer to questions 7 and 8 is no (and 0 otherwise). 1) Is subordinated debt allowable as part of regulatory capital: A. Tier 1 capital? B. Tier 2? If 1.A or 2.B is answered with yes, then the answer to 1 will be considered as yes and 1 point will be added. 2) Are banks required to prepare consolidated accounts for accounting purposes? 3) Do banks disclose to the public off-balance sheet items? 4) Do banks disclose to the public governance and risk management framework? 5) Are bank directors legally liable if information disclosed is erroneous or misleading? 6) Are commercial banks required by supervisors to have external credit ratings? 7) Does accrued, though unpaid, interest/principal enter the bank's income statement while the loan is classified as non-performing? 8) Is there an explicit deposit insurance protection system for commercial banks?
ACTRSTR	Restrictions on banking activities	This variable is obtained as the average of the restrictions level on banking activities. To each of the four activities will be assigned a value between 1-4 which means the activity is unrestricted (1), permitted (2), restricted (3) or prohibited (4). The activities are: 1) Securities activities? 2) Insurance activities? 3) Real estate activities? 4) Can banks own voting shares in	This variable is obtained as the average of the restrictions level on banking activities. To each of the four activities will be assigned a value between 1-4 which means the activity is unrestricted (1), permitted (2), restricted (3) or prohibited (4). The activities are: 1) Securities activities? 2) Insurance activities? 3) Real estate activities? 4) Can banks own voting shares in

		nonfinancial firms?	nonfinancial firms?

Appendix II – Information on bank specific variables

Variable	Description	Bloomberg inputs	Calculation rule
Q1	Loans	Total Loans (BS020)	Q1 = Total Loans (BS020)
Q2	Other earning assets	Total Loans (BS020) Earning Assets (RR141)	Q2 = Earning Assets (RR141) - Total Loans (BS020)
Q3	Total deposits	Deposits (BS041) Short-Term Borrowing and Secs Sold Under Repo (F0636)	Q3 = Deposits (BS041) + Short-Term Borrowing and Secs Sold Under Repo (F0636)
P1	Cost of borrowed funds	Interest Expense (IS022) Deposits (BS041) Short-Term Borrowing and Secs Sold Under Repo (F0636) LT Debt (BS051)	P1 = Interest Expense (IS022) / [Deposits (BS041) + Short-Term Borrowing and Secs Sold Under Repo (F0636) + LT Debt (BS051)]
P2	Cost of physical capital	General and Administrative Expenses (A0181) Net fixed assets (BS032)	P2 = General and Administrative Expenses (A0181) / Net fixed assets (BS032)
P3	Cost of labor	Salaries and Employee Benefits (A0633) Salaries Wages and Employee Benefits (A0008) Total Assets (BS035)	P3 = OR(Salaries and Employee Benefits (A0633); Salaries Wages and Employee Benefits (A0008)) / Total Assets (BS035)
E	Total equity	Total Equity (RR007)	E = Total Equity (RR007) + [abs(min(Total Equity (RR007)))+1]
A	Total assets	Total Assets (BS035)	A = Total Assets (BS035)
TC	Total cost	Interest Expense (IS022) Non-interest exp (RR494)	TC = Interest Expense (IS022) + Non-interest exp (RR494)
PBT	Profit before taxes	Pretax income (RR001)	PBT = Pretax income (RR001)+[abs(min(Pretax income (RR001)))+1]
ROA	Return on assets	Return on Assets (RR028)	ROA = Return on Assets (RR028)
LTD	Net loans to deposits	Net loans (BS022) Deposits (BS041) Short-Term Borrowing and Secs Sold Under Repo (F0636)	LTD = Net loans (BS022) / [Deposits (BS041) + Short-Term Borrowing and Secs Sold Under Repo (F0636)] x 100

LLT	Loan loss to total loans	Total Loans (BS020) Res doubtful debt (BS021)	LLT = Res doubtful debt (BS021) / Total Loans (BS020) x 100
ETA	Equity to total assets	Total Equity (RR007) Total Assets (BS035)	ETA = Total Equity (RR007) / Total Assets (BS035) x 100
CTI	Cost to income	Efficiency Ratio (RR143)	CTI = Efficiency Ratio (RR143)

Appendix III – IMF Country classification and geographical region

Country	Advanced/ Developing economy	Geographical region
Argentina	Developing economy	Latin America & Caribbean
Belgium	Advanced economy	Euro Area
Botswana	Developing economy	Middle East and Africa
Brazil	Developing economy	Latin America & Caribbean
Chile	Developing economy	Latin America & Caribbean
Colombia	Developing economy	Latin America & Caribbean
Croatia	Developing economy	Central and East Europe
Cyprus	Advanced economy	Euro Area
Denmark	Advanced economy	Other Advc
Finland	Advanced economy	Euro Area
France	Advanced economy	Euro Area
Germany	Advanced economy	Euro Area
Ghana	Developing economy	Middle East and Africa
Greece	Advanced economy	Euro Area
Indonesia	Developing economy	Devel Asia
Kazakhstan	Developing economy	Central and East Europe
Kenya	Developing economy	Middle East and Africa
Mexico	Developing economy	Latin America & Caribbean
Morocco	Developing economy	Middle East and Africa
Netherlands	Advanced economy	Euro Area
Nigeria	Developing economy	Middle East and Africa
Pakistan	Developing economy	Middle East and Africa
Peru	Developing economy	Latin America & Caribbean
Poland	Developing economy	Central and East Europe
Portugal	Advanced economy	Euro Area
Russia	Developing economy	Central and East Europe
Spain	Advanced economy	Euro Area
Switzerland	Advanced economy	Other Advc

Country		
United Kingdom	Advanced economy	Other Advc
United States	Advanced economy	Other Advc

Appendix IV – Cost and profit efficiency estimates: mean by country

Country	N	Cost efficiency	Profit efficiency
Argentina	48	0.9113	0.7808
Belgium	13	0.9461	0.7810
Botswana	5	0.9083	0.8468
Brazil	112	0.8677	0.5015
Chile	46	0.9380	0.8033
Colombia	9	0.8182	0.7156
Croatia	2	0.8546	0.8888
Cyprus	3	0.9802	0.8373
Denmark	1	0.9753	0.9246
Finland	2	0.8685	0.9495
France	17	0.9428	0.8873
Germany	12	0.8555	0.7168
Ghana	1	0.9250	0.8212
Greece	45	0.9438	0.8037
Indonesia	209	0.9503	0.7423
Kazakhstan	4	0.9255	0.7753
Kenya	8	0.8683	0.8072
Mexico	2	0.6981	0.9228
Morocco	4	0.7468	0.8461
Netherlands	8	0.9709	0.7428
Nigeria	6	0.7946	0.8963
Pakistan	112	0.9333	0.8521
Peru	9	0.7947	0.8162
Poland	12	0.9085	0.8108
Portugal	43	0.9416	0.7151
Russia	8	0.9522	0.8314
Spain	51	0.9449	0.8741
Switzerland	42	0.9624	0.9285
United Kingdom	29	0.9730	0.7833
United States	2	0.9647	0.2785
Total / Average	865	0.9260	0.7598

Notes:

Cost efficiency: 1/Cost eff. est. (0-1); Profit efficiency: Technical eff. est. (0-1); Values closer to 1 meaning a higher level of efficiency; Efficiency estimates were obtained from the program FRONTIER (Version 4.1c). Sample means have been calculated using bank-year observations (865) and not country observations (30).

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