Essays in Banking Competition, Regulation and Stability

By

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Dedicated to Savvoula Tziatzia and Apostolos Tziatzias

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Summary

The turbulent period of the last decade has highlighted the importance of the financial sector and the need for a flexible set of regulations and due diligence in order to have a healthy, sustainable and prosperous financial system. It has also given rise to important questions about the effect of current regulation and competition policies on the bank's behaviour, economic growth and financial stability.

This thesis has attempted to answer these questions, firstly, by analysing the effect of capital requirements on the UK banks' choice for risk and capital and found evidence that they consider them as complements. This is making the policymaker's decision more complicating as the end result of the bank's stability cannot easily be determined because of that co-movement.

Secondly, this thesis supports the existence of the bank capital channel for the case of the UK commercial banks. The focus is on the composition of their loan portfolio and capital growth following a change in capital requirements. I find evidence of structural change in the bank's loan and capital management approach during and after the financial crisis, with the banks become significantly more responsive to capital requirements changes compared to the period before the crisis.

Thirdly, the competition-fragility is documented for advanced Western economies when using concentration and market power as proxies for competition, while the competition-stability is present when using the Boone indicator which a measure of firm efficiency. Lastly, a strong regulatory framework becomes more beneficial for less competitive markets.

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Chapter 1 Introduction

The deregulation of the years before the credit crunch accompanied by excessive lending due to inefficient supervision have made possible the unusual long lasting turbulent period that we are still trying to recover from ten years later. The critical role of the banking industry in the payments system as well as in facilitating credit for economic growth justifies the attention that regulation and supervision have attracted the last decade. The recent financial crisis has highlighted the importance of systemic risk and the magnitude of the negative externalities that result from bank failures which threaten the overall stability of the economy. It has also made the regulators and the researchers to rethink and reform the role of regulation and supervision, their tools and their impact on the bank's behaviour, financial stability and economic growth. These impacts are the focus of this thesis.

According to Ed Kane(1981) and Buser, Chen and Kane (1981), finance is dynamic and it is responding to and innovating around regulation. This means that the supervisory and regulatory authorities need to balance and adjust all three of their tasks; namely supervise the bank's risk management at the individual level, shield the competition conditions in the industry and ensure financial stability .This thesis examines the impact of regulation and competition on the bank's behaviour and financial stability from the individual's, the industry's and the regulator's

prospective. Initially, I look at the change in risk behaviour of the representative bank as a response to changes in capital requirements. Then I study the effect that the internal target capital ratio has on the assets management approach of the commercial banks in the UK. Finally, I analyse the influence the competition in the banking industry has on the overall financial stability for Western advanced and developing economies. Each chapter analyses how stability is influenced from a different point of view, first from the representative bank's, then from the banking industry's and lastly from the regulator's who observes average country level data for the financial system and the economy.

In Chapter 2 I built a theoretical framework to investigate how a representative bank adjusts its risk and capital management strategies in response to changes in minimum capital requirements. It explains how the capital requirements affect the bank's decision about the risk level of its portfolio and the capital level that it holds. This chapter contributes to the literature as I identify two main indirect effects coming from the change in regulation on the bank's behaviour. The first one is the *profitability effect* which comes through from the fact that higher risk means higher return from the bank's investment. Simultaneously, the second effect, the *insurance effect* shows that the bank wants to be insured against an increase in risk leading to a further increase in capital. Using these effects, the model identifies two cases as to how the banks

view capital and risk. For a sufficiently small risk level the insurance effect is lower than the profitability effect and riskiness and capital are viewed as utility substitutes, while for a sufficiently large risk level the insurance effect dominates over the profitability effect and we have the complements case. In the case of the complements, an increase in capital requirements leads to an increase in both capital ratio and riskiness level while the end result is ambiguous for the substitutes case. The model also offers support to the theory of capital buffers for the UK, since the optimal solution for capital is higher than the threshold set by the regulator. I incorporate that into the model and with an increase in the minimum capital requirements the capital ratio that the bank also increases. I attribute this to the notion that for the bank it is costly to raise capital (especially in a short period of time) after a change in the economic conditions or regulation and this is modelled in my theoretical framework as a potential negative shock at the end of the period that can reduce the value of the capital held by the bank. Finally, following the calibration I show that the UK banks consider capital and risk utility complements and a potential increase of the capital requirements by the regulator will increase both of them leading to partly policy backfiring as the overall increase or decrease of the bank's safeness is unclear. These results hold even after running robustness tests to examine the sensitivity of the results to changes in the parameters used in the calibration.

In Chapter 3 I focus at the effect of capital requirements on bank lending and capital through the impact of the capital surplus/deficit (Gap index) that the banks hold compared to their internal target capital ratio. Since this desired capital ratio is not directly observable, I estimate it using variables known in the literature to affect the bank's capital. I then use it to create the Gap index which shows the distance between actual and target capital ratio. My dataset includes only commercial banks (which are the most important ones for credit supply) in the UK covering a period (1999-2016) of credit booming, the 2007-2009 financial crisis and the recovery period afterward, as well as various regulatory frameworks (Basel I, Basel II and early stages of Basel III) .The majority of the literature looked at a period that stops before the financial crisis or just covers the first 2-3 years of it. Also, most studies only observe the impact of the capital surplus/deficit on the total loans and assets. This chapter also contributes to the literature as I examine the effect that the Gap Index has on the different types of loans (i.e. commercial, consumer, real estate, interbank and other loans).

The results show that an increase in capital requirements (through the decrease of the Gap index), increases the loans with the higher risk weight following Basel II (i.e. commercial and consumer loans) and decreases the ones which carry less weight (Real estate and interbank loans). Thus, following the Basel risk weights they adjust according to what is expected.

However, the banks and the regulators do not include in their calculations the underlying risk of the mortgage loans in a period of economic turbulence which is translated to a decrease in the value of what was offered as a collateral for these loans. The possibility that these result might be different during and after the crisis is examined. I find that they intensify their loan portfolio management during the crisis and their capital ratio after the crisis. Moreover, Provisions for loan losses and Charge-offs act as a deterrent for loans growth. The economic upturn proxied by the GDP growth has a negative effect on capital growth showing that when the economy is in upturn banks take advantage of the high demand in the economy and increase their risk weighted assets (RWA). Lastly, when it is in downturn they shrink credit supply (I find a positive relationship between GDP growth and loans growth) and raise their capital which is increasing their costs and limiting their revenue while they are suffering losses from loan defaults which is not contributing to their survival.

In Chapter 4 I examine the competition-stability nexus using aggregated data on the country level to focus on the overall (rather than the individual bank risk which is usually investigated) of the industry. Lastly, I test the impact of regulation on the competition stability relationship and its linearity. This chapter also contributes to the literature as it studies the EU countries, something that very few studies have done in the past. Specifically, my sample includes the 28 countries of the European Union

and four other Western advanced economies (i.e. USA, Canada, Switzerland and Norway). I use two different competition measures (Lerner, Boone) and one concentration (HHI) for a period (2002-2011) that includes the recent financial crisis. The Lerner and the HHI index support the competition-fragility approach, namely higher market power or concentration lead to greater stability when controlling for macroeconomic, Banking sector-specific and regulatory variables. On the contrary, the Boone indicator supports the theory of competition-stability implying that the benefits of the competition outweighed its shortcomings. I also examine the sensitivity of the results on the regulatory framework in the country and the assumption of linear specification. I find evidence that the benefit in stability from higher supervisory power and more stringent activity restrictions is greater in a less competitive banking industry, but no evidence is present of a U-shaped relationship between competition and stability.

In Chapter 5 I summarise the findings of this thesis and I discuss the policy implications and future research. The banks in the UK consider risk and capital as complements, thus changing both of them in the same direction. This is complicating the decision of the policymaker for change in capital requirements as the level of stability for the bank after its reaction is not easily determined. The UK commercial banks are simply following the regulator's guidance for risk, using mainly the risk weighted

assets, to set their portfolio strategy instead of taking into considerations all risks involved in their decisions. The increased market power and concentration, following the mergers and acquisitions after the crisis, do not seem to have helped the financial stability of the EU and other Western advanced economies. On the contrary, the level of competition as measured by the Boone estimator has increased financial stability.

Chapter 2

Are capital requirements making Banks riskier?

Abstract

The 2007-2009 financial crisis has brought an increase in interest from researchers about the stringent of the banking regulation and capital requiremetns. In this chapter I examine the effect that an increase in capital requirements would have on the bank's choice of risk and capital level using a static model with a representative bank. The results from the theoretical section show that the bank's optimal choice of capital ratio and risk are ambigious depending on whether the bank considers capital and risk as expected utility substitutes or complements. The calibration for the UK that follows favours the complements case, resulting in an increase in both capital and risk after an increase in capital requirements. This leads to the policy partially backfiring as it fails to restrict risk.

   JEL Codes:G21, G28, G33, G38

1   Introduction

The recent financial crisis has highlighted the critical role that the banking industry plays in facilitating credit for economic growth and how important financial stability is for the economy. The deregulation of the years before the credit crunch, combined with excessive lending and unanticipated shocks to borrowers' creditworthiness have led the banking system into a turbulent period that we are still trying to recover from ten years later. This has underlined the importance of an effective set of regulations and due diligence in order to have a healthy, sustainable and prosperous banking industry.

The regulator, in order to achieve these goals, has at his disposal a number of tools and instruments. These include capital requirements, designed to force banks to limit the distress of individual banks by adjusting their risk-taking behaviour or the capital quantity or a combination of both to meet the required target. The increase of the capital ratio should secure the banks further against an unexpected troubled period and the more risk averse behaviour will limit further the probability of a financial crisis. The implication is that policymakers, in their design of capital regulation and supervision level, face a trade off between the potential positive effects the capital requirements have on financial stability and negative on economic growth. They need to balance the benefits with the costs of these decisions in order to maximise the social welfare. Undertaking this type of analysis, however, is difficult without an understanding of how capital requirements affect bank risk taking behaviour and capital management.

The Basel Comittee's answer to the recent financial crisis has been even more

complexity for the bank regulation and supervision, risk management at the individual bank level and use of harmonised policies for different institutional environments. This approach combined with the fact that the regulators allowed the accumulation of such high levels of risk in the banking systems around the world, has led to the question how do capital requirements influence the bank's choice of capital ratio and risk.

A large number of empirical papers show the effects of capital requirements on bank's choices. One of the main arguments in favour of raising minimum capital requirements is that it forces shareholders to keep more "skin in the game", thus reduces the incentives to engage in risk shifting (Demirgüç-Kunt et al., 2010). Akinsoyinu (2015) investigates the impact of capital regulation on the capital behaviour of European large and complex banks during the period 2009 – 2014 and finds that regulation has a positive and significant impact on changes in bank capital. Similar results can be found in Alfon et al. (2004) and Francis and Osborne (2010) when using bank's internal target capital ratios in their models. According to Heid et al. (2004) the coordination of capital and risk adjustments depends on the amount of capital the bank holds in excess of the regulatory minimum (capital buffer). They show that banks with high capital buffers try to maintain them by raising capital and risk simultaneously in response to an increase in capital requirements. In other words, even if the banks meet the capital requirements after the increase they will still decide to increase their capital ratio in response to the stricter regulatory environment.

The capital buffer theory implies that the capital requirements are binding on bank behaviour. In order to test for those co-movements between capital ratios and

capital ratio requirements over time, Aiyar, Calomiris and Wieladek (2012) sort banks into four groups based on the buffer over minimum capital requirements that they were holding. They show that for all four categories of banks, the variation in minimum capital requirements was positively correlated with substantial co-movement between actual capital ratios and minimum requirements. These results are in line with the ones other researchers have found for the UK banks (Alfon et al (2005), Francis and Osborne (2009,2010), and Bridges et al. (2014)).

I construct a theoretical framework to investigate how a representative bank responds to changes in the regulatory environment, and specifically how the capital requirements affect the bank's decision about the risk level of its portfolio and the capital that it holds. As mentioned above and supported by de-Ramon et al. (2016), banks act to maintain buffers above the regulatory thresholds even when regulatory capital requirements are not binding. To incorporate that into the model and explain the motivation that the banks have to hold capital buffers, I include a shock that can alter the value of the capital held by the bank at the end of the period. This shock shows the uncertainty that the bank is facing about the performance of the portfolio and subsequently its utility. The bank is uncertain whether it will meet the capital requirements ex post, and so chooses to hold a buffer to insure against the cost of having to rapidly top up its capital. This analysis is in line with the capital buffer theory, since, as a reaction to an increase in capital requirements a well capitalised bank is expected to increase both the capital ratio and the level of risk while an undercapitalised bank might end up with an optimal combination which has either more or less capital and risk than it had originally (Heid et al. (2004)).

I need to underline at this point the importance of making risk a choice variable for the bank. This Basel approach has been a key contribution to financial crises since the late 1990s. Although the Basel Committee on Bank Supervision(BCBS) treats risk as an exogenous characteristic of assets, in fact it is endogenous. Persaud (2000) and Danielsson et al. (2001) made this point early when Basel II was still under discussion, but the BCBS has not addressed the point. Whether it is requiring banks to have the same risk weights (Basel I) or to use the same or similar models (Basel II and III), the Committee's assumption is that risk is an exogenous property of various assets and that it can be estimated. However, the act of encouraging all banks to look at risk the same way and to reward them when they increase the proportion of 'low risk' assets in their portfolio increases the fragility of the banking sector. Danielsson et al (2001) argue that ignoring the endogeneity of risk is innocuous in normal times but deadly in a crisis, because it encourages a simultaneous run for the exit, that is a simultaneous dumping of assets and drying up of markets for these assets as only sellers are to be found.

The paper most closely related to my chapter is Agur and Demertzis(2015) which is also taking into account the regulator's trade-off discussed above . In Agur's (2015) model the focus is mainly on the effect that the monetary policy has on bank risk and bank capital level. They have a probability of survival for the bank and they use the leverage cap as the regulator's instrument. The rate of return for their investment is exogenous and they do not consider a case in which the state of the world can change and the implications that this may have. Their results depend on whether regulatory capital requirements are binding or not. There are significant differences between my approach and the one that Agur

and Demertzis(2015) follow in terms of model specification and focus of research. My focus of research is not the effect of the monetary policy but the impact of changes in capital requirements have on the representative bank's risk and capital ratio. The rate of return in this model is not exogenous but it is dependent upon the level of risk that the bank chooses. Also, the return on capital is not fixed or known to the bank and the regulator at the beginning of the period and it can be either positive or negative, as it is a shock which follows after a change in the state of the world, and the bank can only form an expectation for it. Finally, I do not come up with two different results for when the capital requirements are binding and when they are not. In this model, the bank has to pay a penalty if at the of the period it does not meet the capital requirements which it takes into consideration when choosin its level of risk and capital at the beginning of the period.

According to Bliss and Kaufman (2002) the regulatory tightening of capital ratios can produce analogous aggregate shocks and, therefore, that prudential capital requirements can influence macro-economic outcomes. Keeping that in mind the regulator faces a trade off. He needs to consider the effects of more stringent capital policies on bank investments and consequently on economic growth and financial stability. In this model, the bank chooses the level of riskiness for its portfolio and the capital that it will hold to maximise its expected utility that it gains from the profit function. The capital requirements are exogeneously set and at the end of the period a shock is realised and the value of the capital that the bank holds is updated. This way, depending on the combination of its profitability and its capital value, the bank may end up in different cases. It can either meet

the capital requirements and have profits or loses or it will pay the penalty for not meeting the capital requirements and again end up with profits or losses.

I identify two main effects coming from the bank's maximisation problem. The first one is the *insurance effect.* After an increase in risk, the bank wants to be insured against it which leads to an increase in capital. At the same time we have the *profitability effect* which comes through from the fact that higher risk means higher return from the bank's investment. This causes the bank to reduce capital in order to expand its investments. The main result of the theoretical model is that it identifies two seperate cases as to how the banks view risk and capital, whether they consider them substitutes or complements. The relationship between the bank's capital ratio and its choice of riskiness after an increase in capital requirements depends on whether the profitability effect or the insurance effect dominates. More specifically, for a sufficiently small risk level the insurance effect is lower than the profitability effect and riskiness and capital are utility substitutes, while for a sufficiently large risk level the insurance effect is higher than the profitability effect and riskiness and capital are utility complements. In the case of complements, an increase in capital requirements leads to an increase in both capital ratio and riskiness level which suggests the policy backfiring. The regulator should not make the bank more risky by increasing the capital requirements, especially if it is not accompanied by an increase on its capital ratio. However, in the case of substitutes an increase in capital requirements the result is ambiguous and it becomes an empirical question to determine which case the bank will end up with, given the specific values of the different parameters of the model. I examine this in Section four for the case of the UK.

The baseline model following the calibration for the UK banks shows that the banks consider capital and risks utility complements and a potential increase of the capital requirements by the regulator will bring an increase of both capital and risk. This is suggesting that the policy is partly backfiring as ideally this should lead to increase in capital and decrease in risk. According to the data and the results I find that, as predicted by the literature, the banks hold capital buffers to insure against potential negative shocks in the economy and to avoid having to bare the cost of rapidly increasing their capital in case of an increase in capital requirements. I run robustness tests to examine if the results are sensitive to changes in the parameters of the calibration and the outcome is that very small fluctuations are observed which do not alter the intuition of the results.

The remainder of this chapter is organised as follows. The model and the bank's maximisation problem is explained in detail in Section two. The implications coming from the outcomes of the model are discussed in Section three. The results from the calibration are analysed in Section four. Section five concludes.

2 The Bank's maximisation problem

In this economy we have one player who is a representative bank and the capital requirements are set exogenously by a regulator. The regulator chooses the capital requirements level ($\underline{k}$) at the beginning of the period such that both economic stability and growth are ensured. The bank has initially a wealth which is normalised to be equal to 1, which could represent the value of its deposits. It can choose at the beginning of the period to either invest or hold as capital (k), so implicitly by choosing the amount of capital that it will hold it also decides how much to invest. In this static model at the end of the period, if there is a shock in the economy, the value of the capital that the bank actually holds changes according to $K = k(1 + \epsilon)$ where ϵ represents the shock and it follows an unknown distribution $\epsilon \sim F(\epsilon)$, where $\epsilon \in [-\infty, +\infty]$. What has been described as a shock in this model can also be considered as the stochastic rate of return for the capital.

The amount of the investment that the bank can choose can be represented by any portfolio that contains risky assets that the bank can get a return from. That risky asset can be loans and the underlying net rate of return of the amount invested in loans follows an unknown distribution and it is denoted by $r \sim G(r)$, where $r \in [-\infty, +\infty]$. The level of risk(x) that its investment will be exposed to is the second choice variable that the bank has. The rate of return on investment is described as rx. Clearly, $E(rx) = xE(r)$ & $Var(rx) = x^2 Var(r)$. So for $x > 1$, investment becomes more risky,but more profitable on average. The bank makes the decision for k and x based on the capital requirements ($\underline{k}$) set by the regulator and the belief it has about the ϵ. The profit function[1] for the bank is:

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[1]The case of the limited liability was also explored, however, because it introduced too many

$$\Pi\left(k,x\right) = \begin{cases} (1+rx)(1-k) + k(1+\epsilon) - 1, & \text{if } k(1+\epsilon) \geq \underline{k} \\ (1+rx)(1-k) + k(1+\epsilon) - 1 - [\underline{k} - k(1+\epsilon)], & \text{if } k(1+\epsilon) < \underline{k} \end{cases} \tag{1}$$

In the profit function the $(1+rx)(1-k)$ shows the gross return on investment, the $k(1+\epsilon)$ shows the return on capital, 1 is the initial wealth. The last term, $[\underline{k} - k(1+\epsilon)]$, is the amount by which the bank needs to top up its capital at the end of the period if it does not meet the regulator's standards, which can be considered as a sanction. The price of the capital is normalised to 1. The bank can end up in different states at the end of the period depending on whether it has profit or losses and on whether the actual capital that it holds at the end of the period (K) meets the regulator's capital requirements or not. If the rate of return for the risky asset is not sufficiently large to compensate for the actual amount held as capital after a potential negative shock has been realised, then the bank will not have a positive profit. If at the end of the period the bank satisfies the capital requirements, i.e., $k(1+\epsilon) \geq \underline{k}$, then no action is taken. If the capital at the end of the period is such that $k(1+\epsilon) < \underline{k}$, then the bank is forced to restore capital by replenishing the shortfall $C = \underline{k} - k(1+\epsilon)$ in order to satisfy the regulatory capital requirements which is assumed that it finances instantly by borrowing any amount necessary from the financial market. The price at which it purchases the new equity is normalised to one. This policy implements a contingent enforcement of a capital requirement. The condition that shows this case is:

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channels it was far from trivial to pinpoint and justify a sign for the second order conditions.

$$k(1 + \epsilon) < \underline{k} \Leftrightarrow \epsilon < \frac{\underline{k}}{k} - 1 \tag{2}$$

According to the literature(e.g. Furfine (2000)), banks choose to hold excess capital to avoid costs related to market discipline and supervisory intervention if approaching or falling below the regulatory minimum capital-ratio. That happens because a poorly capitalised bank risks losing market confidence and reputation, so capital buffers act as an insurance against costs that may occur due to unexpected loan losses and difficulties in raising new capital. This means that even if the capital that the bank chooses at the beginning of the period is equal to $\underline{k}$, meeting the regulator's requirements, it needs to hold sufficiently more than required capital to mitigate the loss of its capital value after a negative shock ϵ is realised. In this model the bank is allowed to suffer losses, as opposed to the case of the limited liability in which their losses are bounded to be non-negative by definition. I assume that the bank's utility function is $U(\Pi|k, x)$ and that it satisfies $U'(\Pi) > 0$ and $U''(\Pi) < 0$ to show that the bank is risk averse. So combining the above with the conditions the bank's expected utility is as follows:

$$
\begin{aligned}
E[U(\Pi|k, x)] \;=\; & \int_{\epsilon = \frac{\underline{k}}{k} - 1}^{\infty} \int_{r = -\infty}^{\infty} U[\Pi(k, x)]g(r)f(\epsilon)drd\epsilon \tag{3} \\
& + \int_{\epsilon = -\infty}^{\frac{\underline{k}}{k} - 1} \int_{r = -\infty}^{\infty} U[\Pi(k, x) - C(\underline{k}, k, \epsilon)]g(r)f(\epsilon)drd\epsilon
\end{aligned}
$$

The first term shows the expected utility for the bank conditional on the bank meeting the regulator's demands at the end of the period, i.e. $\epsilon \geq \frac{\underline{k}}{k} - 1$. In this case the bank holds sufficient capital at the end of the period according to the regulator's

standards and $C(\underline{k}, k, \epsilon) = 0$. The second term shows the bank's expected utility conditional on the bank having a profit but not meeting the regulator's demands at the end of the period, i.e. $\epsilon < \frac{k}{k} - 1$. In this case the bank needs to top up its capital ratio following the regulator's specifications which means that $C(\underline{k}, k, \epsilon) > 0$ causing the bank to decrease its profits or increase its losses. Based on its expected profit function the bank chooses capital and the level of riskiness of its portfolio to maximize it as follows:

$$\max_{k,x} \left\{ E[U(\Pi|k, x)] \right\} \tag{4}$$

This leads to a set of first order conditions. k is chosen to satisfy:

$$\int_{\epsilon=\frac{k}{k}-1}^{\infty} \int_{r=-\infty}^{\infty} U'[\Pi(k, x)]\epsilon g(r)f(\epsilon)drd\epsilon \tag{5}$$

$$+ \int_{\epsilon=-\infty}^{\frac{k}{k}-1} \int_{r=-\infty}^{\infty} U'[\Pi(k, x) - C(\underline{k}, k, \epsilon)](2\epsilon + 1)g(r)f(\epsilon)drd\epsilon$$

$$= \int_{\epsilon=\frac{k}{k}-1}^{\infty} \int_{r=-\infty}^{+\infty} [U'(\Pi(k, x))rx] \, g(r)f(\epsilon)drd\epsilon$$

$$+ \int_{\epsilon=-\infty}^{\frac{k}{k}-1} \int_{r=-\infty}^{\infty} U'[\Pi(k, x) - C(\underline{k}, k, \epsilon)]rxg(r)f(\epsilon)drd\epsilon$$

From (5) we can see that the LHS represents the marginal benefit from an increase in capital since by doing so,because of the limits on the interval, the bank is shifting probability from ending up in the sanction scenario(second term in LHS) toward the profits case(first term in LHS). Since ϵ is the the return on capital, by increasing capital this is what the bank gains by doing so. The RHS represents the marginal cost of increasing capital since intuitively more capital held means

less investment, so since rx is the payoff from investing, this is what that bank is losing. This in turn, would lead to lower profit and lower utility. So x is chosen to satisfy:

$$\int_{\epsilon=\frac{k}{k}-1}^{\infty} \int_{r=0}^{\infty} \left[U'(\Pi(k,x))r \right] g(r)f(\epsilon)drd\epsilon \tag{6}$$

$$+ \int_{\epsilon=-\infty}^{\frac{k}{k}-1} \int_{r=0}^{\infty} \left[U'(\Pi(k,x) - C(\underline{k},k,\epsilon))r \right] g(r)f(\epsilon)drd\epsilon$$

$$= -\int_{\epsilon=\frac{k}{k}-1}^{\infty} \int_{r=-\infty}^{0} U'[\Pi(k,x)]rg(r)f(\epsilon)drd\epsilon$$

$$- \int_{\epsilon=-\infty}^{\frac{k}{k}-1} \int_{r=-\infty}^{0} \left[U'(\Pi(k,x) - C(\underline{k},k,\epsilon))r \right] g(r)f(\epsilon)drd\epsilon$$

The level of risk (x) affects both the expected value and the variance of the rate of return on loans (r). Given that the good state of the economy is when $r \gg 0$, for $x > 1$, we have that the LHS represents the marginal benefit from an increase in x, because of its $E(r)$, the bank enjoys higher profits and higher utility. On the other hand, when $r \ll 0$, for $x > 1$, we are at the bad state of the economy and by increasing x, the bank is more likely that it will suffer losses and lower utility, which is the marginal cost from increasing risk and it is represented by the RHS. Because of the bank's risk aversion, an increase in x in the bad state of the world will bring a more sizeable decrease in utility for the bank than the increase in utility that it would bring in the good state of the world. This is used as a deterrent so that the risk averse bank holds sufficient capital and not excessively increase risk in its portfolio. The conditions for interior maximum are presented in appendix A.

3   Policy implications

It is well established in the literature that when the capital requirements are increased then the banks react by increasing their capital ratio either to maintain their capital buffer or to build an adequate one to avoid market discipline. Additionally, Furfine (2001) shows that there is a positive relationship between regulatory scrutiny of banks and their capital ratios. Theoretically, it has been shown, that although capital adequacy regulation may reduce the total volume of risky assets, the composition may be distorted in the direction of more risky assets. The result may well be an increase in average risk which is referred to in the literature as the moral hazard effect. The empirical literature that has tested this prediction is building on a model developed by Shrieves and Dahl (1992). Following the capital buffer theory, Heid et al. (2004) show that banks with high capital buffers try to maintain their capital buffer by raising capital and risk simultaneously. Also Harris et al. (2014) in a general equilibrium setup suggest that, under competition, increases in capital requirements cause more banks to engage in "value-destroying risk-shifting". In this sense, a policy aiming to reduce bank's exposure to risk by increasing capital requirements may backfire.

3.1   Policy possibly backfiring?

Using the FOC and SOC of the banks maximisation problem I construct figure 1 and figure 2 to show the relationship between the change in capital requirements and the optimal choice that the bank makes for its risk and capital. The line labeled as k^* represents the the bank's optimal choice of capital for every given

level of risk (i.e. the solution to FOC for each given x) and, similarly, the line labeled as x* represents the bank's optimal choice of risk for every given level of capital.

Figure 1: Complements

Figure 2: Substitutes
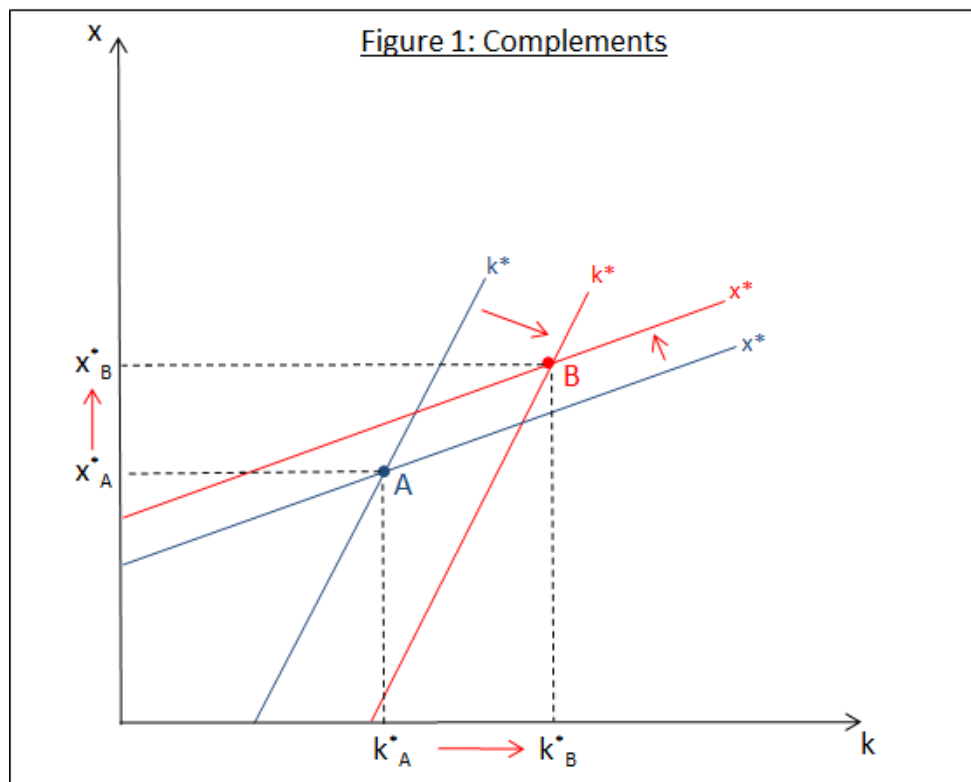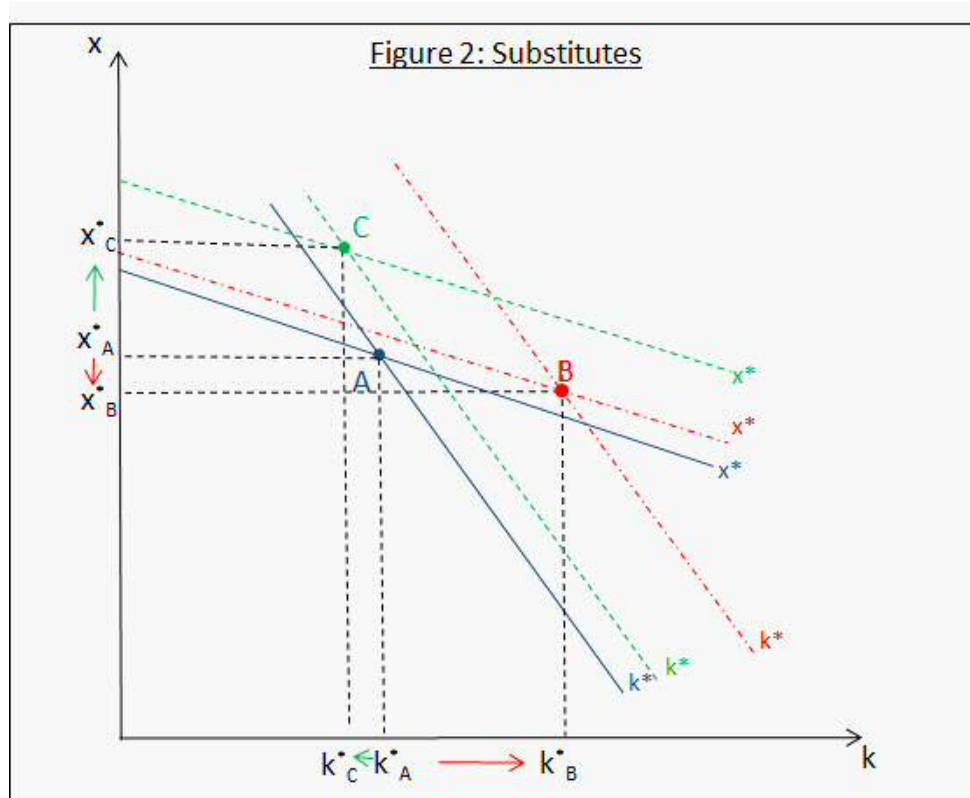
I find the bank's optimal combination of its choice variables, where these two lines meet, as both FOC are satisfied simultaneously. The effect of an increase in risk on the marginal utility of capital can be either positive or negative, making k and x either substitutes or complements. The EU_{kx} determines the slope of the x^* and k^* lines since $EU_{kk} < 0$ and $EU_{xx} < 0$ (Appendix A) in order to have a maximum:

$$\frac{\partial k^*}{\partial x} = -\frac{EU_{kx}}{EU_{kk}}$$

and

$$\frac{\partial x^*}{\partial k} = -\frac{EU_{kx}}{EU_{xx}}$$

The EU_{kx} is shown below:

$$
\begin{aligned}
\frac{\partial^2 E(U(\Pi|k,x))}{\partial k \partial x} \quad = \quad & \int_{\epsilon=\frac{k}{k}-1}^{\infty} \int_{r=-\infty}^{\infty} U''[\Pi(k,x)]r(\epsilon - rx)g(r)f(\epsilon)drd\epsilon \qquad (7) \\
& + \int_{\epsilon=-\infty}^{\frac{k}{k}-1} \int_{r=-\infty}^{\infty} U''[\Pi(k,x) - C(\underline{k},k,\epsilon)]r(2\epsilon + 1 - rx)g(r)f(\epsilon)drd\epsilon
\end{aligned}
$$

The first term shows the case when the bank meets the capital requirements and the second one when it does not. Also, $(2\epsilon + 1 - rx) > (\epsilon - rx) \Leftrightarrow \epsilon > -1$ and following from the SOC I would expect that on average $(\epsilon - rx) < 0$ in order for the problem to have an intuitive meaning. Specifically, in the case that the bank has profits the return from the investment(risky asset) should be greater than the one from the capital (safer asset). We also need $(2\epsilon + 1 - rx) > 0$, since in the penalty case the payoff from capital needs to be greater than the one from investment to motivate the bank to hold some capital, otherwise the bank would hold no capital and accept to pay the penalty since it would be covered by the return of the risky asset. For a large capital ratio (k), because of the limits on the intervals, the first term of this SOC dominates the second one and it is making the whole SOC negative and similarly for small values of k it becomes positive.

Intuitively, I identify two opposing endogenous indirect effects coming through from the increase in x. The first one is the *insurance effect* which makes the bank want to be insured against it and for that reason it increases capital and decreases its investment. The other one is the *profitability effect* which comes through from the fact that higher risk means higher return from the bank's investment which leads to as increase in investment and decrease in capital to exploit the risky asset's higher profitability which leads to higher utility. When the *insurance effect* dominates the *profitability effect* then on average $EU_{kx} < 0$ and if the *profitability effect* is the dominant one the $EU_{kx} > 0$.

The higher the initial risk before the increase, the bigger the insurance effect and the smaller the profitability effect becomes. This is because, the risk averse bank will not consider the additional return coming from the increased risk enough not compensate for the larger probability for losses. In other words, if the bank operates under a sufficiently large risk level then the effect of an increase in risk on the marginal utility of capital is, on average, positive since the insurance effect will be higher than the profitability effect. This means that we can characterise the riskiness and the capital as utility complements. If the bank has chosen a sufficiently small risk level then the effect of an increase in risk on the marginal utility of capital is, on average, negative since the insurance effect is lower than the profitability effect and this means that riskiness and capital are utility substitutes. To analyse the expected result of the optimal choices combination I intuitively consider that $\frac{\partial^2 E(U(\Pi|k,x))}{\partial k \partial \underline{k}} > 0$ and $\frac{\partial^2 E(U(\Pi|k,x))}{\partial x \partial \underline{k}} > 0$ (see appendix B). Furthermore, following the evidence from the literature explained above, I need to assume that $\frac{\partial k^*}{\partial \underline{k}} > 0$ and $\frac{\partial x^*}{\partial \underline{k}} > 0$. Using these assumptions I can go through the two cases

by examining the effects of an increase in capital requirements and the results are shown in Figure 1 and Figure 2.

In the case that riskiness and capital are utility complements, after an increase in capital requirements the bank will respond by increasing its capital ratio to maintain its capital buffer, which is the direct effect from the increase in $\underline{k}$. This will in turn allow the bank to tolerate higher levels of risk, but because in this case, the bank prefers to be overinsured than to enjoy higher returns from the increased level of x, the bank will further increase its capital in order to insure against that extra level of risk. In other words we have that the *insurance effect* is stronger than the *profitability effect* for that bank, which are the indirect effects of a change in $\underline{k}$. This leads to the bank's optimal combination consisting of more capital and a higher riskiness level which suggests that the policy is backfiring, since the regulator by increasing capital requirements should be aiming for an increased capital ratio and a decreased level of risk. As we can see in Figure 1, if the utility maximising combination of optimal x^* and k^* is at point A then an increase in $\underline{k}$ will initially bring an increase in k, This will continue until the bank's optimal choices point gradually moves from point A to point B after the increase in capital requirements.

For the substitutes case, in Figure 2, because both x^* and k^* lines are downward sloping and the result of an increase in capital requirements is ambiguous since it depends on the magnitude of the response of the x^* and k^* lines to that change. After an increase in capital requirements, since k and x are utility substitutes, the two effects might partially offset each other leading to an ambiguous outcome. To see this we need to perform a similar analysis as before,namely an increase in $\underline{k}$

will bring an increase in k,which is the direct effect, and this will in turn allow higher levels of risk. This time, the bank prefers to aim for higher returns from the increased level of x and enjoy the additional profit than to be overinsured against it. This is interpreted as dominance of the *profitability effect* over the *insurance effect,* which are the indirect effects of a change in $\underline{k}$. In Figure 2 this is translated as a move from the initial point A to any point similar to point B(more k and less x) or to any point similar to point C(less k and more x) or any point between them.

4 Quantitative Analysis

Since the theoretical model provided two possible cases for the bank to consider the risk and capital as substitutes or complements it motivates me to perform a quantitative analysis to find clear results. In this section I illustrate the results of the calibration and simulation of the model. In the calibration subsection, I describe a set of benchmark parameters calibrated using U.K. banking data and the exogenously defined parameters. Following that, I analyse the effects of the changes in capital requirements on the bank's choice variables (i.e. x and k).

4.1 Functional forms

In order to show the bank's risk aversion I use the following CARA[2] utility function :

$$U(k, x) = 1 - e^{-c\Pi(k,x)}$$

where c is the absolute risk aversion coefficient and $\Pi(k, x)$ is the profit function as described in (1). In the theoretical model the bank chooses between a risky asset (loans) and a safer asset (capital) and the rate of return of the loans is $(1 + rx)$ and the rate of return of the capital is $(1 + \epsilon)$. I assume that both ϵ and r are normally distributed , so we have that $r \sim N(\mu_r, \sigma_r)$ and $\epsilon \sim N(\mu_\epsilon, \sigma_\epsilon)$.

---

[2]The alternative would be to use a CRRA utility function. However, because it shows the relative risk aversion, the ratio produced using the values for my model did not offer enough variation to return a single internal solution. The best response lines (x^* and k^*) were shown to be identical after a point, giving infinite solutions.

4.2   Algorithm

In the algorithm, I setup the grid for ϵ and r which are set at three standard deviations on either side of its mean capturing the 99.8% of the normal distribution. As the mean of r changes the r's grid is shifting accordingly. Given ϵ, r, k, x I calculate the profit function under the condition that for certain values for k and ϵ there can be two scenarios, one where the bank is meeting the capital requirements at the end of the period and the other one where it does not and it needs to pay the cost of toping up its capital ratio. Based on these two cases I calculate the bank's profit which in turn is used to provide the utility matrix for the bank. Each k and x will provide the the corresponding expected utility ($E[U(\Pi|k,x)$) over the distribution of ϵ and r. For each x I find the corresponding k^* and similarly for each k I find the corresponding x^* which give me the k^* and x^* lines which I use to find the optimal level of capital and risk.

4.3   Calibration

The model is calibrated for the U.K., from data collected from Bloomberg and the S&P Capital IQ platform, using data for the U.K. banks from the period 1997-2016 and from a database used in de-Ramon et al.(2016) to account for a business cycle. There is a set of exogenously determined parameters and another one which results from a grid search by matching empirical moments. Starting with the first set of exogenous parameters, for the ϵ I proxy μ_ϵ and σ_ϵ by the net interest rate income part of the Return on Equity (ROE), which results in $\mu_\epsilon = 0.05$ and $\sigma_\epsilon = 0.085$. I use the same period and banks to get the average

Total Risk Based Capital Ratio (k), which I find to be 14%. Furthermore, using the same dataset,I proxy the probability of the rate of return for the loan to be less than 1 by using the average percentage of loan loss provisions, which is equal to 1%. The last parameter needed is taken from previous research. More specifically, the individual capital requirements ($\underline{k}$) is set to 11.1% and it is taken from de-Ramon et al. (2016) who are using semi-annual data for the period 1989 to 2013 for banks from the U.K..

The second set of parameters consists of μ_r, σ_r and c. To find the values I perform a grid search to match three empirical moments by minimising their Euclidean distance. The moments are the Total Risk Based Capital Ratio (k), the probability of the rate of return for the loan to be less than 1 ($\Pr obFail$ in the algorithm which is equal to 0.01) and the rate of return on loans. The data for all three moments are taken from the database constructed for the U.K. banks from the period 1997-2016. The rate of return on loans that is observed cannot be used directly to calibrate the rate of return on the investment, since in this model, the yield of the investment is not just r but rx and x is endogenously determined. The resulting values of this set of parameters are $\mu_r = 0.5\%$ and $\sigma_r = 0.2\%$ and $c = 189.7$. The absolute risk aversion coefficient(c) is a larger than expected number as I have restricted k to be between $[0,1]$ in order to read the results in percentages and it is a matter of rescaling it to replicate the value expected(usually between 1 and 10). In Table 1 below there are the simulated and empirical moments and their distance. The overall distance has been minimised and it is only 0.0118. In Table 2 there is a summary of the parameters used for the calibration of the baseline model.

Table 1: Empirical Moments matched

Parameters	Capital	ProbFail	r
Simulated	0.1418	0	0.053
Empirical	0.14	0.01	0.053
Distance	0.0018	0.01	0
Overall distance			0.0102

Table 1 shows the Euclidean distance between the simulated and the empirical values of the moments that I match in order to perform a grid search for the mean and standard deviation of the risky asset's rate of return and the absolute risk aversion coefficient. The data used for all three moments are taken from the database constructed for the U.K. banks for the period 1997-2016.

In Table 3 I illustrate the results from the robustness tests to show the sensitivity of the results to changes in the parameters of the calibration. It appears that the optimal k remains the same with all the changes of the parameters and this can be explained by two things. Firstly, the capital is actually fluctuating but by a very small amount and the three decimal points do not allow us to see it. Secondly, as seen in Figure 3, this level of capital seems to be enough for the bank to make sure that it avoids to pay the cost of rapidly raising capital since at the end of the period it will be $k(1 + \epsilon) \geq \underline{k}$. The optimal x fluctuates as expected since an increase μ_r or σ_r will bring a decrease in the additional risk that the bank needs to take(x) maximise its expected utility and similar logic applies for a decrease in μ_r or σ_r. Moreover, the increase in c brings an expected matching decrease in the x^* as the more risk averse bank will choose a lower optimal level of risk. The changes in x^* do not alter the underlying intuition of the results which

Table 2: Baseline model parameters

Parameters	Values
μ_ε	5%
σ_ε	8.5%
μ_r	0.5%
σ_r	0.2%
$\underline{k}$	11.1%
c	189.7
Table 2 summarises the values of the parameters used for the calibration of the baseline model. The data are taken from the database constructed for the U.K. banks for the period 1997-2016.	

suggests that they are robust.

4.4 Capital Requirements

Here I examine the impact of the capital requirements on the bank's optimal choice of risk (x^*) and capital (k^*). Table 4 below shows the effects of a 5% increase and decrease of $\underline{k}$ ceteris paribus. In the first case, when $\underline{k}$ goes up by 5% (from 11.1% to 11.65%), we see that k^* goes up from 13.5% to 14.5% (7.4% increase) and x^* goes up from 10.6 to 10.7 (0.94% increase). In the other case, when $\underline{k}$ goes down by 5% (from 11.1% to 10.55%), we see that k^* goes down from 13.5% to 13% (3.7% decrease) and x^* goes down from 10.6 to 10.55 (0.47% decrease). We see that k is more sensitive to changes of $\underline{k}$ than x is. This outcome confirms the initial assumption that $\frac{\partial k}{\partial \underline{k}} > 0$ and it also shows that $\frac{\partial x}{\partial \underline{k}} > 0$. As explained in the theory section, when x and k are utility complements, an increase (decrease) in $\underline{k}$ will bring an increase (decrease) in both x^* and k^*. The *profitability effect* is dominated by

Table 3:Robusteness tests

Parameters	x*	k*
Baseline	10.60	13.50%
$1.01*\mu_r$	10.50	13.51%
$0.99*\mu_r$	10.70	13.49%
$1.01*\sigma_r$	10.20	13.52%
$0.99*\sigma_r$	11.00	13.49%
$1.01*c$	10.50	13.51%
$0.99*c$	10.70	13.49%
Table 3 illustrates the robustness test reults, showing the sensitivity of the results to changes in the parameters used for the calibration of the baseline model.		

Table 4: Effect of capital requirements change

Parameters	Baseline	1.05*k	0.95*k
x*	10.6	10.7	10.55
k*	13.5%	14.5%	13%
Table 4 shows the effect that a 5% increase and decrease of the level of capital k has on the optimal level of risk (x*) and the optimal level of capital (k*) that the bank would choose, ceteris paribus.			

the *insurance effect leading the bank to choose a more than proportional increase in k* than x when the capital requirements are increased. Also, because of its risk averse nature, the bank chooses to have a smaller reaction to the decrease of $\underline{k}$ than to its increase.

In Figure 3 the x^* and k^* lines are plotted from the calibrated baseline model and where they meet we have the bank's solution to its maximisation problem and according to the graph it is a unique solution. As they are both upward sloping they represent the complements case. For values of x below 10 the corresponding values of k are negative and as it approaches $+\infty$ the corresponding k values asymptotically approach 1. The k^* line appears to be very steep for values of

x below 100 and the corresponding k is around 13.5% which is the optimal k^*. This level of k^* is the one that makes sure that the bank does not pay the cost of purchasing the additional capital needed to meet the capital requirements at the end of period and low levels of x (below 10) cannot secure a high enough return from the investment to cover that cost.

Figure 3: Best response lines for risk and capital
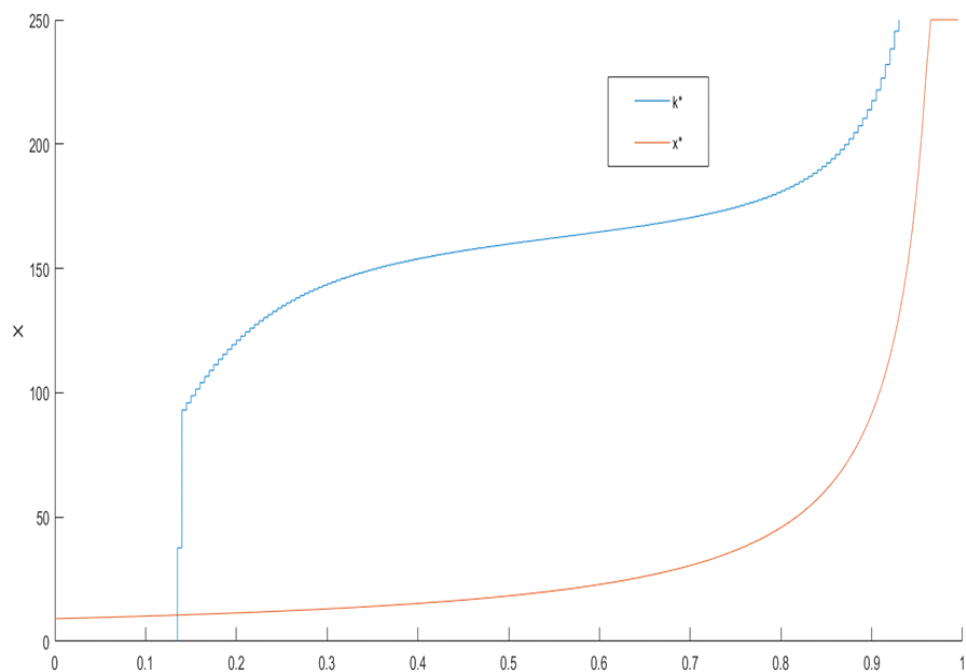
The x* line is the bank's best response for the different levels of capital deriving from the calibrated baseline model. Similarly, the k* line is the bank's best response for the different levels of risk of its portflolio. At the point where they cross we find the optimal level of risk and capital for the bank given the values of the parameters for this model.

Two more things to note about Figure 3 are that the two lines do not cross or converge as x is going to values higher than 250, which means that the two

lines only meet at the point shown in the graph giving a unique solution to the bank's expected utility maximisation problem. The second point to discuss is the substitution area which is not shown in this graph. The reason for that is that it exists for very small values of x which cannot be specified in this graph. This is because the model is calibrated for the U.K. and in this case the optimal x^* is always haigher than these values. So the regulator only observes the complements scenario and sets the capital requirements accordingly and based on that the banks derive their optimal solutions for capital ratio and risk. These results are in line with the notion (Heid et al. (2004)) that better capitalised banks (U.K. banks) tend to maintain their capital buffer after an increase in capital requirements by increasing both capital and the risky assets.

5 Conclusion

In this chapter I develop a static model of a bank in an economy where the regulator determines the level of the capital requirements and the uncertainty about the economic conditions can influence the value of the capital that the bank holds at the end of the period leading to the cost of recapitalising. The model is calibrated using data for the U.K. commercial banks to explain how do banks react to changes of capital requirements when they can adjust their level of risk and capital. The theoretical model provides an ambiguous answer, while the calibrated version clearly points to one of the cases.

The main result is that the banks consider the capital and the risk as utility complements and a potential increase of the capital requirements by the regulator will bring an increase of both capital and risk which is suggesting that the policy is backfiring. Also, there are two indirect effects which are working in opposite directions resulting from the bank's maximisation problem. The first one is the *insurance effect* implying that the bank wants to insure against the increased risk and the second one is the *profitability effect* which comes through from the fact that higher risk means higher return from the bank's investment. This model, in contrast to other models in the literature, is not facing the issue of not binding capital requirements conditions as,according to the results the bank's optimal choice for capital is always higher than the capital requirements.

The policy implications derived from this model are that it is possible for the regulator, by following a more stringent policy, to lead the banks to increase capital and the risk that the bank undertakes. This will happen in order for the return

on their investment to compensate for the cost associated with raising capital to maintain their capital buffer. What's more, the fact the banks will need to increase their capital means that they will have less available funds to invest. This could potentially mean less loans available in the economy which would consequently hinder economic growth. Additionally, a decrease in capital requirements would bring a more than proportional decrease in capital than in risk. These implications would clearly show that the policy could backfire since the regulator should be aiming for financial stability and economic growth. The question that arises is whether the bank is more stable after the change in capital requirements.

Even though it captures the effect of capital requirements on the bank's capital and risk level that is frequently found in the empirical literature, this simple static model has limitations. Firstly, it does not distinguish among the various available loans and investments for the bank, which are accompanied by different risk weights in Basel II and III, which would allow us to observe the risk shifting behaviour of the bank in response to changes in capital requirements. Also, since this is not a dynamic model it does not allow to observe how will the bank behave in the next period if it had to incur the sanction for not meeting the capital requirements which could lead to losses. This would affect next period's available wealth,which in turn would influence its decision for investment. Finally, for future research, from this theoretical model it is possible to extract a reduced form model which will be the basis of an emprical application using bank-specific data.

Appendices

A   Unique solution conditions

I first examine the sign for the EU_{kk} and EU_{xx}. Their mathematical expressions for this model are

$$
\begin{aligned}
\frac{\partial^2 E(U(\Pi|k,x))}{\partial k^2} \;=\; & \int_{\epsilon=-\infty}^{\frac{k}{k}-1} \int_{r=-\infty}^{\infty} U''[\Pi(k,x) - C(\underline{k},k,\epsilon)](2\epsilon + 1 - rx)^2 g(r)f(\epsilon)drd\epsilon \\
& + \int_{\epsilon=\frac{k}{k}-1}^{\infty} \int_{r=-\infty}^{\infty} U''(\Pi(k,x))(\epsilon - rx)^2 g(r)f(\epsilon)drd\epsilon \qquad (8)\\
& - \frac{k}{k^2} \int_{r=-\infty}^{\infty} U'[\Pi(k,x) - C(\underline{k},k,\epsilon)]\frac{k}{k}f(\frac{k}{k}-1)g(r)dr
\end{aligned}
$$

and

$$
\begin{aligned}
\frac{\partial^2 E(U(\Pi|k,x))}{\partial x^2} \;=\; & \int_{\epsilon=\frac{k}{k}-1}^{\infty} \int_{r=-\infty}^{\infty} U''(\Pi(k,x))[r(1-k)]^2 g(r)f(\epsilon)drd\epsilon \qquad (9)\\
& + \int_{\epsilon=-\infty}^{\frac{k}{k}-1} \int_{r=-\infty}^{\infty} U''[\Pi(k,x) - C(\underline{k},k,\epsilon)][r(1-k)]^2 g(r)f(\epsilon)drd\epsilon
\end{aligned}
$$

By using that in this model $U' > 0$ and $U'' < 0$ and that by definition $k \geq 0$ & $\underline{k} \geq 0$ & $f(\frac{k}{k}-1) \geq 0$ we can easily see that both these expressions are negative which means that the solutions for k and x are maximum.

B   Second-order conditions

In the theory section I have considered that $\frac{\partial^2 E(U(\Pi|k,x))}{\partial k \partial \underline{k}} > 0$ and $\frac{\partial^2 E(U(\Pi|k,x))}{\partial x \partial \underline{k}} > 0$. I begin with the first one which shows the impact of $\underline{k}$ on the capital's expected utility. Intuitively I expect this to be positive as by increasing capital require-ments, the capital ratio that the bank holds increases which in turn decreases the probability of ending up in the sanction case. Mathematically to show that it is positive I use that $U' > 0$ and $U'' < 0$. When taking the derivative of $\frac{\partial E(U(\Pi|k,x))}{\partial k}$ with respect to $\underline{k}$ we have:

$$
\begin{aligned}
\frac{\partial^2 E(U(\Pi|k,x))}{\partial k \partial \underline{k}} \quad = \quad & \frac{1}{k} \int_{r=-\infty}^{\infty} U'[\Pi(k,x) - C(\underline{k},k,\epsilon)]\frac{\underline{k}}{k} f(\frac{\underline{k}}{k} - 1)g(r)dr \\
& + \int_{\epsilon=-\infty}^{\frac{\underline{k}}{k}-1} \int_{r=-\infty}^{\infty} U''[\Pi(k,x) - C(\underline{k},k,\epsilon)](2\epsilon + 1 - rx)g(r)f(\epsilon)drd\epsilon
\end{aligned}
\tag{10}
$$

The first term is not negative since $U' > 0$ and by definition $k \geq 0$ & $\underline{k} \geq 0$ & $f(\frac{\underline{k}}{k} - 1) \geq 0$. The second term is positive since $U'' < 0$ and $2\epsilon + 1 - rx$ is expected to be positive as in the sanction case the payoff from capital needs to be greater than the one from the investment to motivate the bank to hold some capital, otherwise the bank would choose no capital and compensate the penalty by the return of the risky asset(rx). The second SOC shows the impact of $\underline{k}$ on the risk's expected utility. Intuitively I expect this to be positive as. The expression showing that is:

$$\frac{\partial^2 E(U(\Pi|k,x))}{\partial x \partial \underline{k}} = - \int_{\epsilon=-\infty}^{\frac{k}{k}-1} \int_{r=-\infty}^{\infty} U''[\Pi(k,x) - C(\underline{k},k,\epsilon)]r(1-k)g(r)f(\epsilon)drd\epsilon$$

(11)

Using again the fact that $U'' < 0$ and based on definition $1 - k > 0$, I expect $\frac{\partial^2 E(U(\Pi|k,x))}{\partial x \partial \underline{k}} > 0$ as on average r is expected to be positive.

Chapter 3

The effect of bank capital surplus/deficit on

loans: Evidence from Commercial banks in the

UK

Abstract

Following the recent financial crisis there has been an increase of interest in understanding how capital requirements affect credit supply and the bank's asset management, in order to avoid similar credit crunches in the future. Most studies only attempt to explain the impact on total lending and not on the various types of lending to different sectors. This chapter contributes to the literature by examining the impact of changes in regulation on various types of loans and capital growth through a Gap index which measures the distance between the bank's internal target and actual capital ratio. I find that with an increase in capital requirements the banks adjust their loan portfolio according to the risk weights in Basel II. Specifically, they decrease the loans with the high risk weight (i.e. commercial and consumer loans) and increase the ones with the low risk weight (i.e. real estate and Interbank loans) while increasing their total capital. Comparing the perios before, during and after crisis I find that the banks adjust their loan portfolio similarly before and after but more sharply during the crisis. Furthermore, they have a much strong reaction to capital requirements changes when adapting their capital ratios after crisis compared to before and during. Finally, There is evidence of the procyclicality effects of capital requirements as I find a negative relationship between GDP growth and capital growth.

1 Introduction

As a response to the various crises globally and to the regulatory reforms over the past three decades, researchers have attempted to analyse the resulting contraction of loan supply using, what is referred to in the literature as, the 'bank capital channel'. What it shows is the linkage between a bank's capital structure and its credit supply. In their attempt to examine this lending channel, they have used a capital gap index which is the difference between the actual capital ratio that the bank holds and an internal capital ratio target that it has (e.g. Hancock and Wilcox (1993,1994), Flannery and Rangan (2006), Francis and Osborne (2009,2010)). The credit crunch witnessed in the recent financial crisis can be partly explained by the "bank capital channel" for the transferal of financial shocks into the real economy.

The idea behind this gap index is that if there is a capital shortfall, then banks will need to alter their balance sheet to close that gap and attain their internal target capital ratio. There are three (Basel II and III which are different risk weights for the various bank's assets) ways they can do that. The first one is to adjust the numerator of their capital ratio by increasing core capital. Alternatively, they can reduce their risk exposure to decrease the ratio's denominator by restructuring their security portfolio or by limiting their loan supply to the economy. Since, especially in the short run, it is difficult and costly to raise capital, banks' optimal adjustment is more likely to be a reduction in loan supply. This will increase the cost of financing for firms and households with significant implications on inflation, investment and economic growth. Obviously, these results will become more severe during a crisis when credit is limited and capital becomes more expensive

(because of increased demand). This makes the supervision and understanding of banks' capital gap and the bank's capital and asset management very important for stability and for conducting monetary policy.

Banking regulation, including capital requirements, has a positive and significant impact on changes in bank capital (Alfon et al. (2004), Akinsoyinu (2015)). More specifically, the banks decide to keep additional capital on top of the minimum regulator requirements since they expect that they may need to in a time of economic distress and they know that it will be very difficult to raise it then. There is evidence (Repullo and Suarez (2012)) to support that they will do so even if that means that they will miss some profitable lending opportunities today. These are pieces of evidence in favor of a theory ("capital buffer theory") which has frequently been used by researchers to explain the relationship between capital and lending, which is in line with the internal target capital ratios.

In most studies which use the target capital ratios, the researchers only attempt to explain the impact of capital surpluses on total lending and not on the various types of lending to different sectors. Also, the majority of the research in this literature has looked at a period that stops before the financial crisis or just covers the first 2-3 years of it. In this chapter, the data I use cover the period of economic booming and deregulation before 2007 starting from 1999 ,the financial crisis (2007-2009) and the recovery period with the stringent regulations and capital requirements afterward until 2016. This chapter also contributes in the literature looking at the impact of the capital surpluses/deficits on the different types of loans (commercial, consumer, real estate, interbank and other loans) by disaggregating the total loans for the commercial banks in the U.K..The results

show that the commercial banks, in response to an increase in the distance between actual and desired capital ratio (i.e. increase in gap), increase their more risky loans (commercial and consumer) and decrease the ones which carry less weight as risk weighted assets. At the same time they choose to decrease their total and Tier 1 capital.

The remainder of this chapter is organised as follows. The summary of the relevant literature is discussed in Section two. The data and methodology used to analyse the impact of capital surplus/deficit on lending and capital growth are described in Section three. The results from the analysis are reported and explained in Section four. Section five concludes.

2 Literature review

Theoretically, there can be arguments about the any direction and size of the effect of a change in bank capital on bank assets and credit supply. For example, one can imagine that a large bank that has easier access to funding for its capital in case it needs to rapidly increase it or an already well-capitalised bank will be able to absorb capital losses without having to reduce its assets and its lending capacity. On the other hand, It can be the case that banks are constantly managing their assets in order to maintain a constant capital ratio (and potentially a capital buffer), because, as capital can be very costly to raise (especially in a turbulent period when many banks need it at the same time), they cannot raise enough equity to counteract declines in their capital which only leaves them the option of reducing their risk weighted assets (among which are loans). Finally, even if the bank can cover the cost of increasing its capital, it could potentially send a negative signal to the shareholders and to the market that it needs a capital top-up since it has become too risky for its current level of capital ratio. To examine these cases for the different periods and countries, the researchers have focused on the relationship between capital ratio and lending and the existence of internal target capital ratios and a bank capital channel.

According to the Modigliani–Miller theorems (Modigliani and Miller(1958)), the banks, except for bankruptcy costs, do not focus on their assets portfolio and capital ratios or their interaction. However, theoretical and empirical research has shown that this does not hold and banks consider the cost of holding capital and that is affecting their portfolio choices. Since it is costly to raise capital, and the

bank has an internal capital ratio target to meet, it could reduce its risky assets. The most significant risky asset, because of its impact on the economy, the bank can reduce is credit supply (e.g. Van den Heuvel (2004), Gambacorta and Mistrulli (2004)). Similarly, according to Adrian and Shin (2008), banks can have a target level of leverage, and in order to reach it after a negative shock to capital (e.g. capital requirements) they would reduce loan supply, leading to procyclical effects of bank capital management. By procyclical effects it is meant that in recessions, losses decrease the banks' capital and, as witnessed in the recent financial crisis, the higher capital requirements that are following it magnify the consequences. If banks cannot recapitalise quickly enough then, because of the new regulations and the turbulent economic environment, their lending capacity can get seriously weakened and this could give rise to a credit crunch.

Some early studies, in conjunction with significant economic events (US recession in 1990), have provided results which prompted an interest in the study of the connection between capital ratios and loans' growth. For example, Bernanke and Lown (1991), to study this relationship they use large and small banks in New Jersey from that period. Their results show that a shortage of capital restricted the small banks' ability to supply loans, even though much of the slowdown was attributed to the decrease in demand from the recession. Two more papers which are have being used as examples in recent literature are the ones by Hancock and Wilcox (1993, 1994) who examine the bank capital channel more directly. They use US bank data to estimate the relationship between bank capitalization and bank-level loan growth, while accounting for loan demand. They define the bank's capitalisation as the difference between actual and targeted capital levels and they

explain that banks that are close to their target their lending will be more sensitive to capital shocks than those banks with relatively high capital surplus. They use in their approach capital adjustment costs to explain why banks need time to adjust to their targeted level.

Heid et al. (2004) examine, for the period between 1993-2000, how the German savings banks' choices for risk and capital altered after changes in capital regulation to test the capital buffer theory. They find that the degree and the nature of these adjustments depends on the size of the excess capital that they hold on top of the minimum capital requirements. Specifically, banks with high capital buffers try to sustain it by adjusting both their capital and their risk toward the same direction(i.e. both increase or decrease). On the other hand, banks with low capital buffers focus primarily on topping up their capital buffer after the increase in capital requirements and at the same time they decrease their risk. Reporting again results from the German banks, Memmel and Raupach (2010) are the first to use the partial adjustment method for the capital for each bank individually by using monthly data. They find evidence that a target capital ratio exists for a large percentage of the banks and that banks with a high target capital ratio also have a high asset volatility and/or a high adjustment speed for their capital. Accordingly, banks with low target capital ratios had low asset volatilities and a high adjustment speed.

Following Hancock and Wilcox (1993, 1994), Berrospide and Edge (2010) use US lending data for large US bank holding companies (BHCs) between covering the period 1992-2008 and find modest effects(annual loan growth of 25 basis points for every one percent increase in capital surplus) of bank capitalization on lend-

ing growth. They too, use a gap index to show the distance between a bank's actual capital ratio and its desired ratio, in a model of lending growth, controlling for a number of bank-specific and macroeconomic variables. They interpret the coefficient on the gap variable as the elasticity of lending growth to changes in bank capital surplus/shortfall. Lastly, they document for banks with higher level of excess capital the growth rate of total loans is greater.

Researchers in a more recent literature (Francis and Osborne (2009,2010), Aiyar, Calomiris and Wieladek (2012,2013)) are using a dataset with confidential data about the individual capital requirements for the UK banks,covering the period before the crisis (1998-2007), to examine the response from changes in minimum capital requirements to lending supply. To begin with, Francis and Osborne (2009) use bank-level data for the UK banks to estimate a partial adjustment long-run internal target risk-weighted capital ratio which they found to be a function of the individual capital requirements set by the regulators and a number of explanatory variables. They further find a negative relationship between capital ratios and the economic cycle using the real GDP growth, which is also consistent with my results.

Francis and Osborne (2010) explain that for a bank capital channel to exist and to have significant implications for the economy, the banks should not hold enough capital to absorb any unexpected regulatory changes, capital should be costly to raise rapidly and that the banks play a key role to credit availability in the economy. In order to find if such a channel exists in the UK they examine whether capital requirements, through their impact on the bank's actual capital ratio, affects the lending supply. By using the internal target capital ratio and its

distance from the actual capital ratio(as in Francis and Osborne (2009)), they find that the capital surpluses (deficits) have positive (negative) association with the growth rate of loans, RWA and total assets' negative (positive) correlation with the growth rate of regulatory capital and tier 1 capital. This is again in line with what I find in my analysis.

Aiyar, Calomiris and Wieladek (2012) attempt to identify whether the capital requirements were binding on bank behaviour, in the sense that the risk-weighted capital ratios move according to the capital ratio requirements over time. To do so they sorted the banks into quartiles based on the excess capital ratio that they were holding on top of the minimum capital requirement (capital buffer). They found that for all four groups, significant and sizable co-movement between minimum requirements and actual capital ratios which was associated with the variation in minimum capital requirements. These results are in accordance with the findings from other studies examined in this literature review for the UK banks(Alfon et al. (2005), Francis and Osborne (2009), and Bridges et al. (2013)).

The components affecting the banks' capital buffer and its impact on lending and capital level(and growth) have received an increase in interest in the academic literature since the beginning of the financial crisis (e.g. Maurin and Toivanen(2012), Bridges et al. (2014),Noss and Toffano (2014) and de-Ramon et al. (2016)). All these studies also use a partial adjustment model of capital ratio toward the target capital ratio of the banks to analyse empirically the banking sectors in the UK, the US and the Euro area.

Firstly, Maurin and Toivanen (2012), provide evidence of the impact of capital gap on lending and portfolio management from banks in the euro area (for the

first time) for the period 2005-2011. They first positively associate the bank's balance sheet risk with its target capital ratio. Then, they show evidence of a certain hierarchy in the way the bank is adjusting its risky assets by documenting a more sizeable impact of the adjustment procedure toward higher capital ratios on security holdings compared to loans. Noss and Toffano (2014) use a VaR model (closely related to the one in Berrospide and Edge (2010) which they augment by using sign restrictions) to estimate the effect of changes in capital requirements applied to all UK-resident banks on lending by studying the joint dynamics of the aggregate capital ratio of the UK banking system and a set of macro-financial variables. They find that an increase in the aggregate bank capital requirement during an economic upswing is associated with a decrease in lending greater for lending to firms than to households.

De-Ramon et al. (2016) use confidential regulatory returns data for the UK banking industry from 1989-2013 to find the association between capital requirements and the bank's capitalisation level and then the effect of the latter on the growth rate of its assets (loans, RWA, total assets) and its capital (total regulatory capital and Tier 1). They use the gap index to do so and the focus of their paper is whether the financial crisis has been a structural break in the way the banks manage their capital and assets in response to changes in regulation. Their initial findings are in agreement with the previous studies, namely, they find a positive relationship between banks' capital ratios and capital requirements and that it holds even when the requirements are not binding. The significant finding of their study is that there is some difference between before and after crisis adjustments of the banks's capital and assets growth rate to the regulatory changes. Specifically, they

show that banks post crisis placed more weight on overall asset de-leveraging and that they increased better quality capital (Tier 1) significantly more in response to higher capital requirements. On the contrary they do not find an equivalent change for the effects of capital requirements on lending and risk-weighted asset growth after the crisis.

3 Data and Methodology

In this section, I explain the dependent and explanatory variables that I will be using in the estimation models in addition to the data and the sources that I am using. I then explain the approach I followed to estimate the target capital ratio for each bank in my sample. The second step is to calculate the gap index which is the measure of bank capitalization and it is showing the capital surplus or deficit the bank has compared to that internal target. The last step is to go through the model which I am using to estimate the effect that the capital surplus/deficit has on the bank's loans, other assets and capital growth. Finally, I explain the estimation technique and the reasons why I have used it.

3.1 Data sources and variable definitions

Since the focus of my chapter is the lending supply, I concentrate on examining the behaviour of UK commercial banks, which have typically played a large role in supplying credit to consumers and firms in the economy. More specifically, to limit the heterogeneity among the banks in my sample I only use the large commercial banks which operate domestically with total assets over £1 billion. Banks specialising in investment or private banks or banks which have most of their operations abroad are not included as they are a lot more exposed to risks from the international markets and they could subject to a set of regulations in other countries as well influencing their capitalisation and lending strategy. I further restrict the sample by eliminating any banks which were not active during the financial crisis and banks which offer less than 10 years worth of observations

in order to account for a complete business cycle. The data reported are at the unconsolidated level because in the UK the individual capital requirements are at the level of the individual as well as at the group (consolidated) level. This means that individual banks inside a banking group will need to adjust their asset portfolio and capital to meet the regulator's requirements and the individual's behaviour is of interest in this analysis. The initial sample included 32 UK banks which are characterised as commercial banks from Bankscope database, however as explained, they have either a large part of the operations abroad or a small part of their operations involves domestic lending. After applying these restrictions the number of banks left in the sample is 16 covering for the period 1999-2016.. The sample still contains the largest banks which hold a high percentage of the market share (more than 90% of the market share is held by the top 20 banks based on their asset size as shown in Figure 1). Therefore, it includes these banks which are of most interest to a regulator concerned with financial stability which makes this sample representative. All the data used in this analysis (apart from the GDP growth which is sourced by the World Bank's World Governance Indicators(WDI)) are sourced by S&P CapitalIQ.

Figure 1: Market share of UK commercial banks grouped based on their asset size
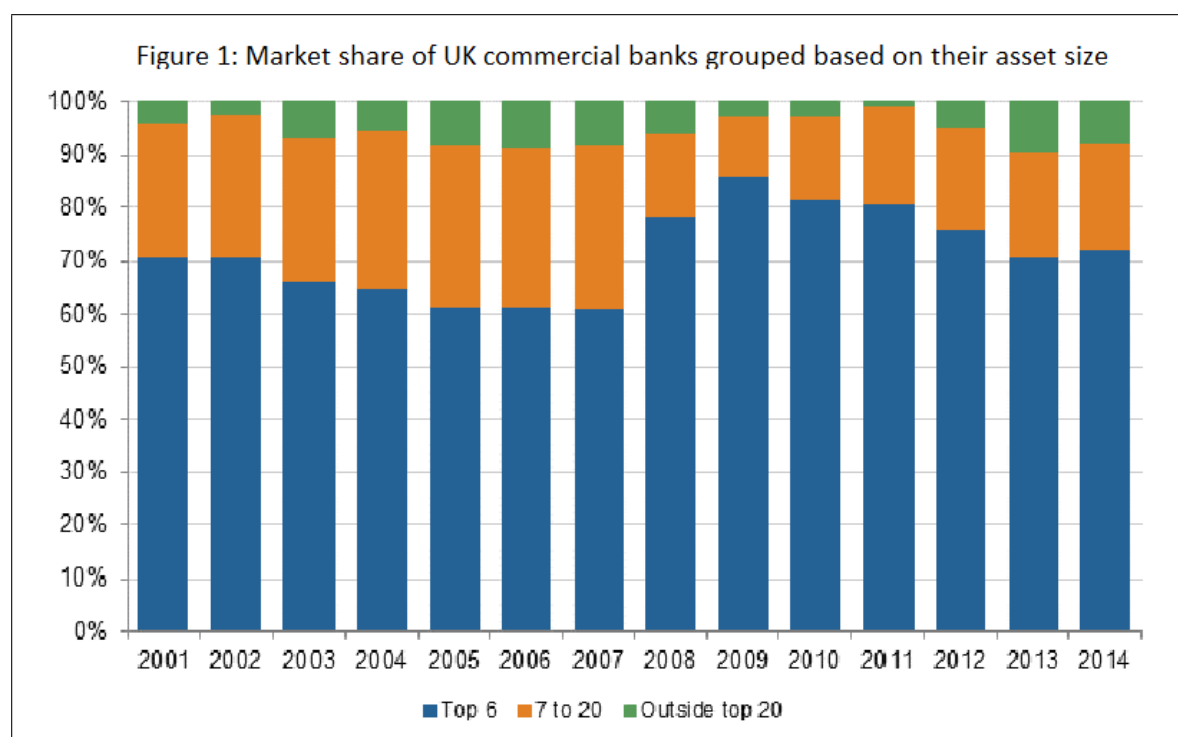
Source: www.cml.org.uk

Next I define the variables I use for my estimations. For the target capital ratio (Equation 6) I use:

Tier 1 Capital Ratio %: Tier 1 Capital as a percentage of Total Risk-Weighted Assets of the Bank. Tier 1 capital includes the sum of a bank's equity capital, and its disclosed reserves and non-redeemable, non-cumulative preferred stock.

Total Risk-Based Capital Ratio %: The ratio of total risk-based capital to risk-weighted assets. The total risk-based capital ratio is the total of the core capital ratio.

ROE %: Amount of net income returned for the company as a percentage of average total equity. This variable measures the company's profitability. Calculated as:[Net Income / Average total equity of Current and Prior Period] * 100.

Total equity includes Common Equity and Preferred Equity.

Trading Book (TB) %: Assets held by a bank that are regularly traded over Total assets.

Provision for loan losses%: The periodic expense for possible future loan losses. Could be negative when there is a recovery of loan losses. May include other provisions if they are not disclosed separately.

For the estimation of the effect of Gap on different assets and capital growth(Equation 8) I use:

Net Charge-Offs %: Ratio of actual loan losses charged-off in the period to average total loans (in percentage). Calculated as: (AnnualizedActualLoan-Losses/AverageTotalLoan)*100.

Interbank loans: Short-term interest-earning loans to banks except the central bank. Includes call loans, receivables from other banks. Includes federal funds sold and securities purchased under agreements to resell. Include Federal funds sold and repurchase agreements. Includes deposits at interest with other banks.

Real Estate loans: Represents commercial real estate loans, construction loans and multi-family real estate loans. Also includes 1 - 4 Family Real Estate Loans, Real Estate Mortgage loans and loans given for the construction of residential houses.

Commercial Loans: Loans for commercial and/or industrial uses. Includes agricultural loans and financing transactions with commercial clients, i.e. bills of exchange, bills discounted, overdrafts, and other bills. Construction loans are shown net of undisturbed loans in process. Includes short-term loans. Includes Money Market Loans.

Consumer Loans: Loans for consumer and/or individual uses. Includes install-ment loans, credit card loans, installment loans are net of unearned income and deferred loan fees. Gross of provision for loan losses.

Other loans represents loans given by the Bank other than Commercial Domes-tic Loans, Construction Loans, Commercial Mortgage Loans, Residential Mortgage Loans, Consumer Loans, Foreign Loans, and Lease Financing.

Total Assets (SIZE): The total of all short and long-term assets as reported on the Balance Sheet. This is the sum of Cash & bank balances, Fed funds sold & resale agreements, Investments for Trade and Sale, Net loans, Investments held to maturity, Net fixed assets, other assets, Customers' Acceptances and Liabilities.

Other assets: Total assets - Total loans.

GDPG %: Real annual percentage growth rate of GDP on local currency.

In Table 1 below we find the descriptive statistics on the variables used in this chapter. The average capital ratio for my sample is 13.58 percent which is higher than the minimum capital requirement of 8 percent. This is consistent with the capital buffer theory explained earlier which states that the banks hold a buffer over the minimum requirement to reduce the associated costs from a sudden change in regulation policy. Also, the percentage of tier 1 capital of the total capital is high showing that the quality of the capital the commercial banks in the sample hold is of high quality. Combined with the fact that many of the banks in the sample can be considered as large banks (using the average Total Assets) it shows that large banks hold higher quality capital and that they do not hold very high capital ratios (de-Ramon (2016) record capital ratio of 18.3 percent for a sample including more small and medium banks) as they have easier access to funding

and they have more diversified portfolios. However, the high capital ratios are mainly driven by the period after the financial crisis and most of its increase is attributed to the decrease of RWA (risk weighted assets) rather than the increase in capital when I divide the sample into pre and post crisis. Furthermore, from the percentage of Trading Book to Total Assets we see that some banks do not hold, almost, at all any liquid assets while the average value of 17.7 percent shows a moderate share of their business. However, this is an average value of before and after crisis. Before 2009 the average was 18.2 percent and after the crisis the average fell to 16.9 percent. Before 2008, many banks had placed a lot of assets that looked like they belonged in the banking book (in some cases CDOs) into the trading book, possibly to take advantage of lower capital requirements. This issue was recognised by the Basel Committee in 2009 and it thorough reviewed the trading book. The extreme values of the average loan growths show the credit boom before the crisis and its devastating results.

Table 1: Summary statistics

Variables	Observations	Mean	Standard Deviation	Minimum	Maximum
Total risk based Capital ratio	282	13.58	3.57	1.3	27.1
Tier1 Capital/Total Capital	279	72.89	20.11	10.05	83.02
Loan Provisions/Total Assets	288	0.92	3.3	-0.92	32.53
ROE	288	9.35	17.7	-41.45	64.37
Trading Book/Total Assets	259	17.67	8.77	0.17	42.91
Total Assets(£Millions)	288	577461.9	698668	1208.1	1992218
Commercial loans growth	270	2.22	4.75	-35.99	35.06
Consumer loans growth	226	5.01	5.42	-53.03	48.35
Real Estate loans growth	185	5.46	0.87	-6.79	6.33
Interbank loans growth	267	2.36	5.71	-34.03	20.95
Other loans growth	181	-0.9	0.87	-4.85	6.99
Other Assets growth	240	1	5.61	-25.34	28.82
Capital growth	224	8.1	14.21	-15.66	45.09
Tier 1 growth	253	2.4	20.82	-41.39	45.16
Charge_Off	241	0.68	0.79	-0.45	6.29
Change in Provisions	273	0.01	1.37	-8.45	17.89
GDPG	288	2.07	1.79	-4.33	3.74

3.2   Target capital ratio estimation

Alfon et al.(2004), after interviewing banks and building societies in the UK con-
clude that firms differentiate between their desired level of capital and their actual
level of capital. In order to model each bank's target capital ratio $(k_{b,t}^*)$ I follow
the literature (e.g. Hancock and Wilcox (1993, 1994), Francis and Osborne (2009),
Berrospide and Edge (2010), Maurin and Toivanen (2012), de-Ramon(2016)) and
I use the notation from the latest paper (i.e. de-Ramon(2016)). The target ratio
is estimated as a function of a explanatory variables $X_{n,b,t}$ (the variables included
along with the justification for using them can be found below when explaining
Equation 6) including bank specific factors and a constant (α_b) for each bank which

captures idiosyncratic factors such as business model, management, risk aversion and the mix of markets in which the bank operates. This specification takes the following form:

$$k_{b,t}^* = \alpha_b + \sum_{n=1}^{N} \zeta_n X_{n,b,t} \tag{1}$$

For the next step it needs to be assumed that, because the cost of raising capital is high, the banks do not immediately adjust their capital and assets to changes in their target capital ratio. They do so gradually and it is time-consuming so they are following a partial adjustment process as found in Berrospide and Edge (2008) and Hancock and Wilcox (1994). As a result, the change in the capital ratio in each period is a function of the gap between the target and actual capital ratio in the previous period:

$$k_{b,t} - k_{b,t-1} = \lambda(k_{b,t-1}^* - k_{b,t-1}) + \epsilon_{b,t} \tag{2}$$

where $k_{b,t-1}$ is the actual capital ratio of bank b at time t-1, λ is the adjustment speed at which $k_{b,t}$ reaches its target $k_{b,t}^*$, and $\epsilon_{b,t}$ is the error term. For the partial adjustment model to be meaningful $\lambda \in (0,1)$, since a value of $\lambda = 0$ would mean that the bank is not adjusting its capital to its target at all and $\lambda = 1$ would mean that it adjusts it within one time period which would contradict the assumption of the model. Another assumption is that λ is the same for all banks. Substituting

(1) into (2) and rearranging results in the model below and its estimation outputs are shown in Table 2:

$$k_{b,t} = (1 - \lambda)k_{b,t-1} + \lambda(\alpha_b + \sum_{n=1}^{N} \zeta_n X_{n,b,t-1}) + \epsilon_{b,t} \tag{3}$$

For the long-run parameters, α_b and ζ_n, from the results of estimating (3), taking into account the implied value of the adjustment speed. To bring it in a form which will be closer to the one I estimate we can rewrite (3) as:

$$k_{b,t} = A_b + A_1 k_{b,t-1} + \sum_{n=1}^{N} B_n X_{n,b,t-1} + \epsilon_{b,t} \tag{4}$$

where $A_b = \lambda\alpha_b$, $A_1 = (1 - \lambda)$ and $B_n = \lambda\zeta_n$, so to get the long run effect of each explanatory variable is given by:

$$\zeta_n = \frac{B_n}{\lambda} \tag{5}$$

I will now specify what are the explanatory variables included in the $X_{n,b,t}$ vector. Following again the studies which have used the above partial adjustment model I use some of the variables which they have found to be significant in estimating the target ratio. First, to account for the cost of capital, I include

the return on equity (ROE). One important factor considered by Estrella (2004) is the cost for firms of holding capital, although in practice measurement of this cost is difficult. Prior studies (e.g. Ayuso et al. (2004); Bikker and Metzemakers (2004); Stolz and Wedow (2005); Jokipii and Milne (2008)) employ banks' return on equity (roe), the ratio of post-tax earnings to book equity, as a proxy of the direct opportunity cost of holding equity capital. Under this cost interpretation, we expect to observe a negative relationship between risk-based capital ratios and the ROE variable. Then, the ratio of tier 1 capital to total regulatory capital (tier1) is used to account for the quality of the capital held by the bank. It also is a proxy for the cost of capital, since if it is more costly for banks to adjust equity, then we expect that cost-minimizing banks will hold higher total risk-based capital ratios and, therefore, to observe a positive correlation between risk-based capital ratios and tier1. To control for different business models in banks with large trading books, which could make the bank riskier, I add the ratio of trading book assets to total assets (tb). To proxy for the riskiness of the bank, I use a measure that shows the bank's own estimation of risk, as it is the expected future loan losses. More specifically I use the ratio of loss provisions to total assets (provision). Finally, it is expected that larger banks tend to hold smaller capital buffers as they have a greater ability to diversify their portfolio and better access to funding sources(which also reduces the cost of capital) I add the log of total assets to proxy for the bank's size (size). Previous studies have found significant evidence in support of this effect (e.g. Alfon et al. (2004) Stolz and Wedow (2005) and Jokippi and Milne (2008)). We expect the association between risk-based capital ratios and size to be negative, since larger firms may achieve greater economies of scale in screening risky borrowers and better diversification of risk

across asset classes and geographic locations. To proxy for the potentially higher costs associated with adjusting equity capital (e.g., direct transaction and indirect signalling costs that could adversely impact share prices), previous studies (e.g. Alfon et al. (2004) Wong et al. (2005)) have also included lagged values of the capital ratio ($k_{b,t-1}$). These variables transform (4) into the baseline target capital model that I estimate:

$$
\begin{aligned}
k_{b,t} &= A_b + A_1 k_{b,t-1} + B_{roe}roe_{b,t-1} + B_{tb}tb_{b,t-1} + B_{provision}provision_{b,t-1} \quad (6) \\
&\quad + B_{tier1}tier1_{b,t-1} + B_{size}size_{b,t-1} + \epsilon_{b,t}
\end{aligned}
$$

3.3 Capital surplus/deficit index

After estimating the target capital ratio, I construct the capital surplus/deficit measure for each bank. I calculate the target ratios for each bank using the long-run coefficients derived (using equation (5)) with the short-run parameters estimated in equation (4) and applying them to the target capital model set out in equation (1). A bank's capital surplus or deficit in terms of the actual capital ratio relative to this target capital ratio is calculated as:

$$
Gap_{b,t} = 100 * \left[\left(\frac{k_{b,t}}{k_{b,t}^*}\right) - 1 \right] \quad (7)
$$

If the Gap is negative(positive) it means that the bank has a lower(higher) capital ratio that its desired long-run capital ratio target. This would mean that in order to reach its target it can decrease(increase) its assets(e.g. by decreasing lending supply or by increasing the lending interest rates or by investing in less risky assets) or/and increase(decrease) its capital level (e.g. by issuing new equity or by retaining profits or by decreasing dividend payouts). Figure 2 below shows the average Gap for each bank over time. For the part before the financial crisis commercial banks seemed to hold higher capital ratios than their desired ones (the line is above 0). From 2007 to 2010 they is a decrease in their Gap leading to a capital deficit (the line is below 0). This can be attributed to the initial decrease of their capital because of loan losses or/and to changes in their target ratio because the financial crisis created a very risky and unstable economic environment. After 2010, the average line is increasing and it stays in positive values after making the adjustments that I examine below.

The green and red lines show the 75th percentile and 25th percentile, respectively. The important difference between the two lines is the crisis period. The better capitalised banks compared to their target (i.e. green line) do not seem to negatively affected on average during that period showing that they probably had a highly diversified portfolio and easy access to capital. The worse capitalised banks compared to their target (i.e. red line) were shocked by the financial crisis, creating significant capital deficits. In response they had to drastically alter their portfolio composition and/or raise substantial amounts of capital with potentially significant consequences to their profits and cash flows. An optimistic sign about the future is that all three lines converge to positive and high capital surpluses,

reinforcing the belief that today commercial banks in the UK are becoming well capitalised again.

Figure 2: Capital surplus measure (Gap index)
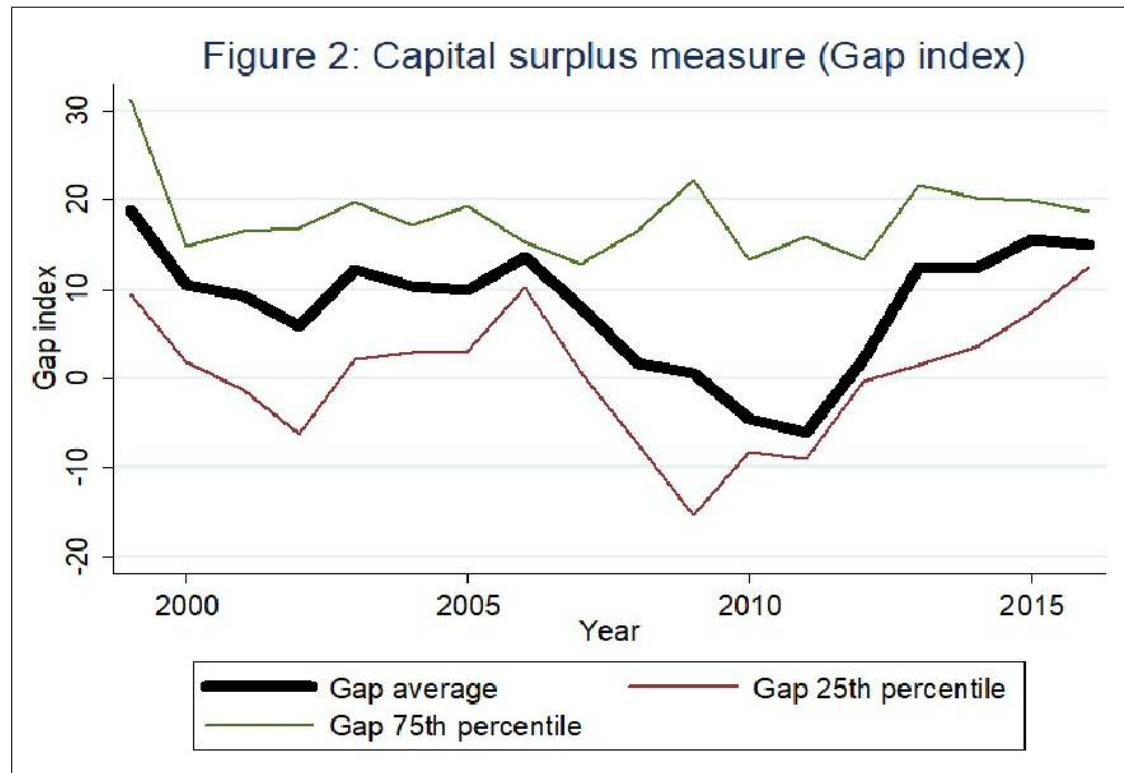
3.4 Baseline model and Methodology

After calculating the Gap index, I regress the following model to examine the significance of the lagged dependent variable. The estimated persistence of the lagged dependent variable, expressed by its coefficient, is significant for all types of assets examined here. This analysis suggests that the growth rate of assets and capital is best characterised by a dynamic, autoregressive process. Thus, I use

the following dynamic model to estimate the effect that the Gap index has on the bank's loan portfolio and capital growth[1] :

$$\begin{Bmatrix} \Delta \ln Assets_{j,b,t} \\ \Delta \ln Capital_{g,b,t} \end{Bmatrix} = \gamma_b + \alpha_j \begin{Bmatrix} \Delta \ln Assets_{j,b,t-1} \\ \Delta \ln Capital_{j,b,t-1} \end{Bmatrix} + \beta_{Gap} Gap_{b,t-1} + \delta_{PROV} \Delta PROVISIONS_{b,t}$$

$$+ \delta_{CO} CHARGEOFF_{b,t} + \theta_{GDPG} GDPG_{b,t-1} + \epsilon_{b,t} \qquad (8)$$

where $\Delta \ln Assets_{j,b,t}$ is the annual growth rate at time t of the jth asset examined here (i.e. Commercial loans, Consumer loans, Real estate loans, Other loans and Other assets) for bank b. The $\Delta \ln Capital_{j,b,t}$ is the annual growth rate at time t of the gth capital examined here (i.e. Total regulatory Capital and Tier 1 capital) for bank b. I also include the gap index that I calculated earlier. The $Gap_{b,t-1}$ variable is the main variable of interest in this specification and if it increases then this means that the bank's capital surplus(deficit) is increased(decreased). A significant coefficient for the $Gap_{b,t-1}$ would mean that the bank is altering its asset composition(or capital), in order to close the gap between the actual and the desired capital ratio. Moreover, to proxy for the bank's own estimate of asset risk I include the change in the ratio of loss provisions to total assets ($\Delta PROVISIONS_{b,t}$) and higher (lower) ratios suggest more (less) risk. Potentially, what can be said is that a negative association with capital ratios may interline moral hazard behaviour. Alternatively, a positive association may

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[1]The Gap index might be subject to a generated variables bias as explained by Pagan (1984). It can bias the standard errors upwards, making it possible to reject the statistical significance of the Gap coefficient even though it is significant (Type 2 error). In this case the Gap index (in the results from table 4 & 5) is significant which means that even if a generated variable bias exists it is not large enough to make its coefficient insignificant, so it is not influencing the results substantially.

imply evidence of market discipline. The ratio of the net charge-offs of a bank over its total assets ($CHARGEOFF_{b,t}$) is included to control for bank-specific credit conditions. To account for changes in the macroeconomic conditions and demand for credit during the business cycle, I include the lagged annual real GDP growth ($GDPG_{b,t-1}$). A variable capturing international risk (VIX) was also included in the specification, however it was only significant at the 10% significance level for the capital growth so it was removed. This is in contrast to what was found in the de-Ramon et al. (2016) paper, where VIX was also included in a similar specification and it was significant for the capital and total assets. The difference is that in their paper they include a number of investment banks with international operations and commercial banks which have a significant part of their operations abroad, which is making them more vulnerable to international risk than the commercial banks in my sample. Lastly $\epsilon_{b,t}$ is the error term.

In order to test whether the effect of the Gap index has changed during the crisis or after the crisis compared with its effect before 2008 I construct the following specification:

$$
\begin{aligned}
\begin{Bmatrix} \Delta \ln Assets_{j,b,t} \\ \Delta \ln Capital_{g,b,t} \end{Bmatrix} =\ & \gamma_b + \alpha_j \begin{Bmatrix} \Delta \ln Assets_{j,b,t-1} \\ \Delta \ln Capital_{j,b,t-1} \end{Bmatrix} + (\beta_1 + \beta_2 D_{cr} + \beta_3 D_{post})_{Gap} Gap_{b,t-1} \\
& + \delta_{PROV} \Delta PROVISIONS_{b,t} + \delta_{CO} CHARGEOFF_{b,t} + \theta_{GDPG} GDPG_{b,t-1} \\
& + D_{cr} + D_{post} + \epsilon_{b,t}
\end{aligned}
\tag{9}
$$

where D_{cr} is a dummy variable that gets the value 1 if $2007 < t < 2010$ and 0 otherwise and D_{post} is a dummy variable that gets the value 1 if $t \geq 2010$ and 0

otherwise. The marginal effects of bank capitalization during the crisis and post-crisis periods are given by $\beta_2 D_{cr}$ and $\beta_3 D_{post}$ respectively. After the specification is regressed for the short-run, the coefficient of the lagged dependent variable is used to calculate the long-run effect of a change in bank capitalization on the balance sheet component j. This is expressed by:

$$\frac{\vartheta \Delta^{\Delta \ln Assets_{j,b,t}}_{\Delta \ln Capital_{g,b,t}}}{\vartheta Gap_{b,t-1}} = \beta_1/(1-\alpha_j), \text{ before crisis}$$

$$\frac{\vartheta \Delta^{\Delta \ln Assets_{j,b,t}}_{\Delta \ln Capital_{g,b,t}}}{\vartheta Gap_{b,t-1}} = (\beta_1 + \beta_2)/(1-\alpha_j), \text{ during crisis}$$

$$\frac{\vartheta \Delta^{\Delta \ln Assets_{j,b,t}}_{\Delta \ln Capital_{g,b,t}}}{\vartheta Gap_{b,t-1}} = (\beta_1 + \beta_2 + \beta_3)/(1-\alpha_j), \text{ after crisis.}$$

3.5 Estimation technique

Because of the small number of banks in my sample and the unbalanced panel in conjunction with the not very large T (18 years) the available options for estimating my models are limited and all have weak points which are described here.

Since I focus on the relationship between gap and the growth rate of the bank's assets, I use only three more explanatory variables to account for other things that will affect the bank's asset management. In this case fixed effects would be useful as they would be able to control for unobserved heterogeneity macroeconomic and demand-side effects at any point in time (e.g. decrease in demand for loans because of an economic downturn). Even though I include the growth of the GDP to account for the business cycle, the time fixed effects would have been better at soaking up all factors common to banks without the need to model them. The

reason why I cannot use them is that I am estimating a dynamic model with the system GMM approach and using time or bank fixed effects, given the number of observations in my sample, would increase the number of instruments that would have been used very much (even if there is not exactly a number that makes the number of instruments "too many") and with the first difference the fixed effects are removed.

As I mentioned before, the models I am estimating are dynamic which means that lagged dependent variables are used as regressors. And as shown in my results in Tables 3, 4 and 5 the lagged dependent variables are (apart form one) significant so I should not estimate the model without them. According to Nickell (1981) the existence of both lagged dependent variables and fixed effects causes a well-known bias. However, Judson and Owen (1999) show that is better to use standard fixed effects estimation rather than GMM in unbalanced panels when T is large (T>30), as the bias declines as the number of time period increases, and the results of the estimation will be consistent (given there is no autocorrelation of the error terms). But as my sample spans for 18 years it is still not large enough to be considered consistent. An additional issue arises because methods that involve pooling data (such as the fixed effects estimator and other panel methods) assume homogeneity of coefficients across banks. Pesaran and Smith (1995) suggest using the Mean Group estimator to tackle this issue. However, the unbalanced nature of my panel means that this estimator is not appropriate. That is because the Mean Group estimator would give a very large weight to coefficients estimated for banks with only few observations, leading to very high standard errors. Kiviet (1995) argues that the best way to handle dynamic panel bias is to perform LSDV(Least Square

Dummy Variable), then correct the results for the bias, which he finds can be predicted with great precision. However, the approach he explains works only for balanced panels and does not address the potential endogeneity of other regressors.

I am using the system Generalized Method of Moments (GMM) to estimate my models which is developed by Arellano and Bond (1991) and then improved by Blundell and Bond (1998). This GMM estimator instruments the differenced variables that are not strictly exogenous with all their available lags in levels. In this equation, variables in levels are instrumented with suitable lags of their own first differences. It ensures efficiency and consistency provided that the models are not subject to serial correlation of order two and that the instruments used are valid which are tested using the AR(2) and the Sargan/Hansen testing for the validity of instrument subsets which are offered automatically with the system GMM method.

I collapse the instrument matrix by using the Windmeijer (2005) error terms to limit instrument proliferation. I restrict the number of lags to limit the number of instruments used. Finally, according to Arellano and Bond (1991) and Windmeijer (2005) the two-step estimated standard errors have a small-sample downward bias in dynamic panel data setting, which is corrected by applying the Windmeijer (2005) error terms.

4 Empirical results

In this section I analyse the results from the estimation of the target capital ratio and the short-run and long-run effects of the capital surplus/deficit on the bank's assets and capital growth. Before that, in Table 2 I find the Pearson's correlation matrix. The first thing to notice is that the Gap (the lag capital surplus/deficit) is negatively associated with the capital and Tier 1 growth and positively correlated(most of them are significant) with some of the loans which is showing the bank's behaviour in response to changes in the Gap. Also, Provisions and Charge offs brings are positively correlated with Capital and Tier 1 growth and influence negatively most of the loans' growth acting as a deterrent. Finally, the GDP growth's negative correlation with Capital growth shows the latter's procyclicality.

Table 2: Correlation matrix

Variable	Gap	Capital Growth	Tier1 Growth	Commercial Growth	Consumer Growth	Real Estate Growth	Interbank Growth	Other Loans Growth	Other Assets Growth	Provissions change	Charge Off
Capital Growth	-0.4006 (0.0000)	1									
Tier1 Growth	-0.2308 (0.0009)	0.2238 (0.001)	1								
Commercial Growth	0.0422 (0.0615)	0.0437 (0.532)	-0.0191 (0.7767)	1							
Consumer Growth	0.0202 (0.0959)	0.12 (0.1066)	0.04 (0.5786)	-0.1438 (0.0311)	1						
Real Estate Growth	-0.0242 (0.0852)	0.1252 (0.1511)	0.1511 (0.0686)	-0.2323 (0.002)	0.7642 (0.000)	1					
Interbank Growth	-0.1111 (0.1049)	0.1255 (0.0681)	-0.0439 (0.5006)	0.0636 (0.3299)	0.0141 (0.8407)	-0.0797 (0.3304)	1				
Other Loans Growth	-0.0169 (0.1431)	-0.2211 (0.0084)	0.0352 (0.6636)	0.0724 (0.3438)	0.1179 (0.1622)	0.1374 (0.1397)	-0.0994 (0.2125)	1			
Other Assets Growth	0.1059 (0.0724)	0.1887 (0.0114)	0.0441 (0.5422)	0.0979 (0.1584)	-0.1076 (0.1563)	-0.4372 (0.000)	-0.0549 (0.429)	0.0997 (0.2462)	1		
Provission change	-0.046 (0.0082)	0.0525 (0.4437)	0.0805 (0.217)	-0.0038 (0.0932)	-0.0126 (0.0561)	-0.0553 (0.0903)	-0.0401 (0.5267)	-0.074 (0.3604)	-0.0008 (0.9905)	1	
Charge Off	-0.1093 (0.1463)	0.0925 (0.0267)	0.1009 (0.1061)	-0.0666 (0.3369)	-0.113 (0.1069)	-0.096 (0.2663)	-0.0606 (0.0769)	-0.0091 (0.9141)	-0.0077 (0.9197)	0.0802 (0.0428)	1
GDP Growth	0.1469 (0.0365)	-0.1521 (0.0265)	-0.137 (0.0331)	0.029 (0.6462)	-0.0502 (0.4675)	0.0053 (0.9441)	-0.1754 (0.0049)	0.001 (0.9898)	0.0666 (0.3181)	-0.05679 (0.0634)	-0.151 (0.0218)

4.1 Capital ratios

In Table 3 below I summarise the short-run for the explanatory variables that affect capital in equation (6) and the long-run coefficients using equation (7). The coefficient on the lagged capital ratio implies a moderate adjustment of capital ratios to target. The estimated average speed of adjustment is around 41% per time period. This estimate is in line with studies using US data that covers earlier periods from our study. Berrospide and Edge (2010) and Berger et al. (2008), find adjustments speeds between 28%-40% annually. Francis and Osborne (2009) using UK before the financial crisis estimate speeds around 30% while de-Ramon et al. (2016) find very high speeds around 64%.

For the rest of the bank-specific explanatory variables they all have the expected sign, however three of them are marginally significant at the 10% significance level. ROE and Tier 1 appear to be highly significant and they are negatively and positive correlated with capital ratios respectively. The Return On Equity is used to proxy capital costs so an increase in ROE increases the opportunity cost of holding capital, thus justifying the negative sign. The positive relationship between capital ratios and Tier1, shows as the share of Tier1 capital increases the banks tend to hold higher total capital as well. This is because it is very costly to raise this higher quality capital and the banks which have a large percentage of Tier 1 capital, hold high capital buffers to avoid it.

The sign of the Size adds evidence to the idea that the larger the banks are the easier and cheaper it is for them to access any additional funding needed and the better diversified their portfolio is, which allows them to set lower capital buffers

than smaller banks. The bank's trading book (TB) is positively correlated with the capital ratio in the long run which implies that the higher the banks' involvement is in trading activity the higher their capital ratios tend to be. Lastly, Provisions for loan losses increase capital ratio indicating that as the bank's estimate for its asset portfolio risk is increasing it chooses to further insure against any potential negative shocks by raising its capital.

Table 3: Capital target ratios (Short-run and Long-run)

VARIABLES	(1) Baseline Short-run	(2) Baseline Long-run
Lag Capital	0.591***	
	(0.084)	
Provisions	0.376*	0.92*
	(0.174)	(0.548)
ROE	-0.053***	-0.13***
	(0.00558)	(0.0129)
TB	0.064*	0.156*
	(0.0305)	(0.075)
Tier1	0.33***	0.806***
	(0.102)	(0.245)
Size	-0.199*	-0.487*
	(0.103)	(0.2518)
Constant	1.918*	4.689*
	(1.083)	(2.648)
Observations	206	206
Number of Banks	16	16
No of instruments	16	16
AR(1) (p-value)	0.004	0.004
AR(2) (p-value)	0.362	0.362
Sargan (p>chi2)	0.000	0.000
Hansen (p>chi2)	0.539	0.539
Prob>F	0.000	0.000

*Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.10. In column (1) the system GMM regression estimates are reported of the determinants of UK banks' target capital ratios in Equation (6). The dependent variable is the ratio of the total capital over the risk weighted assets at time t. In column (2) the long-run transformation of the results is shown by dividing the coefficients of column (1) by the capital's adjustment speed. The adjustment speed is calculated as 1-λ, where λ is the coefficient of the lagged capital variable from column (1). The p-value of the Hansen test of validity, the p-value of the Sargan test of over-identifying restrictions and the p-value of the first-order autocorrelation test (AR(1) and AR(2)) are reported. The p-value of the F stat of the equation is shown in the last row.*

The consistency of the system GMM estimator depends both on the assumptions that the error term is not auto-correlated as well as on the number and validity of the instruments used. In Tables 3, 4 and 5 three important types of tests are shown. The first test (AR(1) and AR(2)) examines the hypothesis of no autocorrelation in the error term. The presence of first-order autocorrelation (rejecting the null hypothesis for the AR(1)) in the first difference does not imply that the estimates are inconsistent. However, the presence of second-order auto-correlation (rejecting the null hypothesis for the AR(2)) implies that the estimates are inconsistent. The second one is the Sargan test of over-identifying restrictions. Rejecting the null hypothesis means that the results are weakened by the use of many instruments. The third one is a Hansen test, which examines the validity of the instruments. Rejecting the null hypothesis means that the instruments used are not robust. In all these tables (3, 4 & 5) the AR(1) test and the Sargan test are rejected and the AR(2) test and Hansen test cannot be rejected at 10% significance level and in most cases at 1% and 5% significance level. These results from the tests do not indicate a reason to question the validity of the instruments used or the consistency of the estimates.

4.2   Portfolio adjustments to capital surplus/deficit

In this section, I use the target capital ratios from above to construct the Gap index (capital surplus/deficit) to analyse the short-run and , more importantly, the long-run effects that it has on the different types of loans, other assets and capital growth. The results of the estimations are shown below in Table 4 for the short-run effects and in Table 5 for the long-run effects. As explained before, the gap index shows the distance between actual capital ratio and target ratio for each bank. Based on the way the Gap has been calculated, a positive gap would mean that the bank has a capital surplus compared to its desired one and it tends to decrease the former in order to reach that internal target ratio. Consequently, what is expected when the gap is positive is for the bank to try to adjust its asset by decreasing the capital that it holds and/or increase the amount of loans and other assets (and potentially its level of risk) in its balance sheet to benefit from their expected return. In both tables we see this behaviour from the commercial UK banks in my sample.

More specifically, we have the main variable of interest (Gap) which appears to be significant for almost all the assets apart from the Interbank loans. Given that, the important part becomes the sign of its impact on the growth rates of these assets. In most studies(e.g. Francis and Osborne (2009), de-Ramon (2016)) which examine the impact of the gap on the growth of total loans and assets the sign is positive. From the results found in the Tables 4 and 5 the sign for total loans growth is unclear but it is not important as this is not the focus of this work. However, what is of interest in this study is that with the specification in Equation (8) we can see the way the banks adjust their loan portfolio in order to achieve

their target capital ratio in response to changes in the economic environment of regulations. These changes might be an increase in capital requirements which would bring a decrease in the Gap index.

For both consumer and commercial loans (which carry 50-100% weight in RWA) growth, the effect of gap is positive and significant and it shows that as the gap is increasing the bank increases its lending for individuals and commercial uses. Specifically, for an increase in gap by 1% it will increase the annual consumer and commercial loans growth by 0.4 pp and 0.3 pp respectively in the short-run and 0.24 pp and 0.2 pp in the long-run. Real estate and Other assets (which carry 50-100% and 0-20% weight in RWA respectively) growth are negatively impacted by the Gap. The coefficient for the real estate and Other assets growth show that for an increase in gap by 1% it will decrease the annual consumer and commercial loans growth roughly by 0.2 pp and 0.3 pp respectively in the short-run and 0.1 pp and 0.3 pp in the long-run. As I said before, the coefficient for Interbank growth is very small and insignificant. Even though, gap negatively affects Other loans (0.15 pp and 0.07 pp in short-run and long-run respectively) the value of Other loans is a small fraction compared to the other loans and assets of the bank's loan portfolio. So, overall these results show that when the bank's capital ratio surplus increases(capital deficit decreases) and become better capitalised(closer to its target), they tend to reduce the amount of safer (according to RWA Basel II weights) investments and increase the amount of riskier (and more profitable) ones, while decreasing their total capital and Tier 1.

Table 4: Loans and Capital determinants (Short-run)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	Commercial	Consumer	RealEstate	Interbank	OtherLoans	OtherAssets	Capital	Tier 1
Lag Gap	0.0420***	0.0254*	-0.0170**	0.040	-0.0150***	-0.027**	-0.158***	-0.0282***
	(0.013)	(0.0131)	(0.0065)	(0.0821)	(0.00127)	(0.0115)	(0.0331)	(0.007)
ΔProvisions	-0.443**	-0.966	-1.20	-3.99***	-4.19***	-1.15	-1.19*	-0.16
	(0.155)	(0.899)	(8.88)	(0.290)	(1.54)	(6.78)	(0.667)	(0.27)
Charge_Off	-0.609**	-0.0958**	-0.467***	-0.896***	-0.161	-0.0777	-0.0595	-0.461***
	(0.0221)	(0.0344)	(0.141)	(0.180)	(0.126)	(0.0190)	(0.401)	(0.105)
GDPG	0.412***	-0.0638**	0.00250	-0.926	1.023***	0.216	-0.120	-0.53**
	(0.013)	(0.0275)	(0.0229)	(1.74)	(0.144)	(0.112)	(0.235)	(0.242)
L.Commercial	-0.736***							
	(0.110)							
L.Consumer		-0.319***						
		(0.0424)						
L.Real_Estate			-0.676***					
			(0.156)					
Lag Interbank				-0.124***				
				(0.0397)				
L.Other_Loans					-1.119***			
					(0.0887)			
L.Other_Assets						0.0133		
						(0.124)		
L.Capital							0.116***	
							(0.0299)	
L.Tier1								0.274***
								(0.0381)
Constant	-0.789*	2.886**	0.510***	-2.81	-2.359***	-0.652	2.361***	0.366*
	(0.439)	(1.214)	(0.08)	(3.99)	(0.313)	(2.427)	(0.719)	(0.187)
Observations	148	126	96	162	108	120	137	158
No of Banks	15	13	13	15	14	13	15	15
Instruments	14	14	10	14	10	14	14	14
AR(1)(p-value)	0.007	0.008	0.011	0.023	0.069	0.148	0.074	0.034
AR(2)(p-value)	0.243	0.235	0.744	0.579	0.630	0.723	0.837	0.306
Sargan(p>chi2)	0.000	0.001	0.000	0.050	0.000	0.001	0.000	0.000
Hansen(p>chi2)	0.759	0.614	0.369	0.627	0.792	0.453	0.373	0.249
Prob>F	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.10. The system GMM regression estimates are reported of the short-run effects of Gap on asset growth as found in equation (8). In columns (1)-(5) the dependent variables are the growth rates of the different types of loans at time t, in column (6) the dependent variable is the growth rate of the other_assets = total assets- total loans at time t, in columns (7) the dependent variable is the growth rate of the ratio of the total capital over the risk weighted assets at time t and in column (8) the dependent variable is the growth rate of Tier 1 capital as a percentage of total risk weighed assets at time t. The p-value of the Hansen test of validity, the p-value of the Sargan test of over-identifying restrictions and the p-value of the first-order autocorrelation test (AR(1) and AR(2)) are reported. The p-value of the F stat of the equation is shown in the last row.

Table 5: Loans and Capital determinants (Long-run)

VARIABLES	(1) Commercial	(2) Consumer	(3) RealEstate	(4) Interbank	(5) OtherLoans	(6) OtherAssets	(7) Capital	(8) Tier 1
Lag Gap	0.0242***	0.0193*	-0.01**	0.0036	-0.0071***	-0.0276**	-0.179***	-0.039***
	(0.07)	(0.01)	(0.004)	(0.07)	(0.0006)	(0.012)	(0.0374)	(0.01)
ΔProvisions	-0.255**	-0.73	-0.716	-3.55***	-1.97***	-1.17	-1.35*	0.22
	(0.09)	(0.68)	(5.3)	(0.26)	(0.727)	(6.87)	(0.75)	(0.37)
Charge_Off	-0.351**	-0.073**	-0.278***	-0.79***	-0.0759	-0.079	-0.0673	-0.635***
	(0.0127)	(0.026)	(0.084)	(0.16)	(0.06)	(0.0193)	(0.454)	(0.145)
GDPG	0.237***	-0.048**	0.0015	-0.82	0.483***	0.219	-0.136	-0.73**
	(0.0075)	(0.021)	(0.017)	(1.55)	(0.068)	(0.114)	(0.266)	(0.333)
Constant	-0.455*	2.19**	0.3***	-2.5	-1.113***	-0.66	2.67***	0.504*
	(0.253)	(0.92)	(0.05)	(3.55)	(0.148)	(2.459)	(0.814)	(0.258)
Observations	148	126	96	162	108	120	137	158
No of Banks	15	13	13	15	14	13	15	15
Instruments	14	14	10	14	10	14	14	14
AR(1)(pvalue)	0.007	0.008	0.011	0.023	0.069	0.148	0.047	0.034
AR(2) (pvalue)	0.243	0.235	0.744	0.579	0.630	0.723	0.837	0.306
Sargan(p>chi2)	0.000	0.001	0.000	0.050	0.000	0.001	0.000	0.000
Hansen(p>chi2)	0.759	0.614	0.369	0.627	0.792	0.453	0.373	0.249
Prof>F	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.10. The system GMM regression estimates are reported of the long-run effects of Gap on asset growth in equation (8). The results presented here are the long-run transformation of the results shown in Table 4 by dividing the coefficients of the explanatory variables by the adjustment speed of the dependent variable for each column. The adjustment speed is calculated as 1-λ, where λ is the coefficient of the lagged dependent variable for each column. In columns (1)-(5) the dependent variables are the growth rates of the different types of loans at time t, in column (6) the dependent variable is the growth rate of the other_assets = total assets- total loans at time t, in columns (7) the dependent variable is the growth rate of the ratio of the total capital over the risk weighted assets at time t and in column (8) the dependent variable is the growth rate of Tier 1 capital as a percentage of total risk weighed assets at time t. The p-value of the Hansen test of validity, the p-value of the Sargan test of over-identifying restrictions and the p-value of the first-order autocorrelation test (AR(1) and AR(2)) are reported. The p-value of the F stat of the equation is shown in the last row.

Despite the fact that provisions are significant for some of the assets, its relatively high coefficient for almost all loans shows that it acts as a strong detergent for loans growth expansion. The Charge off is highly significant for loans (except Other loans) and it has the expected sign (negative). Lastly, the growth of GDP has a positive impact on Commercial and Real Estate loans, which could potentially imply that during an economic expansion the increase in the investment in

the economy and a potential decrease in unemployment creates demand for these types of loans which drives their supply as well. What needs to be mentioned here is what looks like a counterintuitive sign of the GDP growth for the Consumer loans (even though its value is very small). This does not suggest that an increase in the growth of GDP would decrease the supply of Consumer loans. Given that we are dealing with growth rates for all the dependent variables, it means that an increase in the GDP growth will slow down the growth rate of Consumer loans. Since commercial loans are risky and in many cases unsecured (e.g. credit cards), during a growth period the banks might want to slow down the growth of their risky side of the portfolio. Thus, a potential explanation is that it might be a representation of prudential behaviour.

Finally, there is a strong impact of the capital surplus and the Capital and Tier 1 growth which is negative and highly significant as expected and in line with the literature. As the bank's capital ratio moves away from its target the banks tend to reduce the growth of the total capital and tier 1 capital that they hold. The percentage by which they do that is 0.16 pp and 0.02 pp for total capital and tier 1 capital respectively in the short-run and 0.18 pp and 0.03 pp in the long-run for every 1% increase in capital surpluses. This result means that as a respond to a change in policy (increase in capital requirements) the percentage increase of the total capital will be more than the one of the high quality Tier 1 capital justified by its greater cost to raise. I find some evidence of a negative relationship between capital ratios and the economic cycle over recent years, consistent with previous literature (de-Ramon (2016)), indicate their countercyclical nature. This combined with the positive relationship found in the literature between capital

requirements and capital surplus give rise to potential procyclicality of the capital requirements which requires the attention of the policymakers when setting them.

In Table 6, I examine if the effect of Gap is different in the during and post-crisis period compared to the pre-crisis period using the specification found in Equation 9. By looking at the interaction term about the period during the financial crisis (Lag Gap*Dcr) we find that it is significant and higher than the pre-crisis period for the loans (apart from the Interbank loans) and other assets but not statistically significant for the capital and Tier 1 variables. This means that during the crisis the banks focused on changing their loan portfolio to adjust to the regulator's will and not the capital and Tier 1 ratios. It can be explained by the fact that capital, especially during a financial crisis, is very expensive and difficult to raise so the banks had to meet their capital requirements by adjusting their loan portfolio more intensely than before the crisis.

On the other hand, the interaction term about the post-crisis period (Lag Gap*Dcr) is statistically significant for the Capital, Tier 1 and other assets variables but not for the loans (apart from the very small in value other loans). This says that the banks continued to adjust their loan portfolio similarly as they were doing before the crisis but they greatly intensified (especially for Tier 1 which is the most loss absorbent capital type) their adjustment procedure for their capital by increasing even more their capital ratio (both total and Tier 1) with an increase in capital requirements compared to the pre-crisis period. This enhances the notion that the UK banks became better capitalised after the crisis, especially after the QE from the Bank of England and the announcement of the Basel III new capital requirements and regulations.

Table 6: Loans and Capital determinants during and after crisis (Long-run)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	Commercial	Consumer	RealEstate	Interbank	OtherLoans	OtherAssets	Capital	Tier 1
Lag Gap	0.032***	0.025*	-0.008**	0.0045	-0.0085***	-0.02**	-0.158***	-0.056***
	(0.09)	(0.015)	(0.004)	(0.08)	(0.0009)	(0.014)	(0.039)	(0.011)
Lag Gap*Dcr	0.05**	0.033*	-0.011**	-0.03	-0.005**	-0.01*	-0.092	0.00
	(0.013)	(0.027)	(0.005)	(0.03)	(0.002)	(0.008)	(0.073)	(0.012)
Lag Gap*Dpost	0.01	0.012	0.003	0.041	0.011**	-0.01**	-0.21***	-0.148***
	(0.016)	(0.019)	(0.006)	(0.062)	(0.004)	(0.004)	(0.06)	(0.05)
ΔProvisions	-0.3**	-1.22	-0.944	-3.55***	-1.97***	-1.17	-1.35*	0.22
	(0.07)	(1.18)	(4.6)	(0.26)	(0.727)	(6.87)	(0.75)	(0.37)
Charge_Off	-0.402**	-0.068**	-0.307***	-0.69***	-0.109	-0.054	-0.081	-0.722***
	(0.0174)	(0.029)	(0.091)	(0.15)	(0.16)	(0.021)	(0.49)	(0.159)
GDPG	0.301***	-0.032**	0.0025*	-0.65	0.392***	0.177	-0.174	-0.98**
	(0.011)	(0.014)	(0.011)	(1.4)	(0.092)	(0.199)	(0.308)	(0.398)
Dcr	0.237*	-0.048*	0.0015	-0.82	0.483*	0.219	-0.136	-0.7
	(0.0075)	(0.021)	(0.017)	(1.55)	(0.068)	(0.114)	(0.266)	(0.333)
Dpost	0.237*	-0.048*	0.0015	-0.82	0.483*	0.219**	-0.136	-0.73
	(0.0075)	(0.021)	(0.017)	(1.55)	(0.068)	(0.114)	(0.266)	(0.333)
Constant	-0.24*	1.79**	0.14**	-1.11	-2.02**	-0.41	4.55***	0.177*
	(0.15)	(0.61)	(0.04)	(1.83)	(0.8)	(1.65)	(1.1)	(0.09)
Observations	148	126	96	162	108	120	137	158
No of Banks	15	13	13	15	14	13	15	15
Instruments	18	18	14	18	14	18	18	18
AR(1)(pvalue)	0.006	0.006	0.013	0.035	0.088	0.11	0.04	0.022
AR(2) (pvalue)	0.37	0.43	0.673	0.63	0.51	0.881	0.69	0.391
Sargan(p>chi2)	0.000	0.003	0.000	0.04	0.000	0.001	0.000	0.000
Hansen(p>chi2)	0.65	0.488	0.26	0.55	0.711	0.62	0.325	0.3
Prof>F	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.10. The system GMM regression estimates are reported of the short-run effects of Gap on asset growth in equation (8). In columns (1)-(5) the dependent variables are the growth rates of the different types of loans at time t, in column (6) the dependent variable is the growth rate of the other_assets = total assets- total loans at time t, in columns (7) the dependent variable is the growth rate of the ratio of the total capital over the risk weighted assets at time t and in column (8) the dependent variable is the growth rate of Tier 1 capital as a percentage of total risk weighed assets at time t. Dcr is a dummy variable which takes the value 1 for the financial crisis period 2007<t<2010 and 0 otherwise. Dpost is a dummy variable which takes the value 1 for the period after the financial crisis t>2009 and 0 otherwise. The p-value of the Hansen test of validity, the p-value of the Sargan test of over-identifying restrictions and the p-value of the first order autocorrelation test (AR(1) and AR(2)) are reported. The p-value of the F stat of the equation is shown in the last row.

4.2.1 Policy implications

The above results can also be used to explain what would have happened if there was an increase in capital requirements. Since this would bring a decrease in the Gap the bank would increase its real estate loans and decrease the consumer and commercial ones. This needs to be examined further and deeper to understand what are the implications. Even though they might appear moderate in size, they show the bank's response and its (and more importantly the regulator's) underestimation of the underlying risks associated with such behaviour. Despite the fact that, following the Basel II risk weights definitions, the bank is making the right choice, if an economic crisis hits the economy (e.g. housing bubble) then the losses from the real estate loans would be more significant than the ones from the consumer and commercial loans.

Initially, same for all loans, because of the crisis there would be some borrowers who would not be able to pay their debt and default, leaving the bank with losses. The masked, additional risk, of the theoretically safer mortgage loans is that in a period of crisis the real estate market is suffering as well. Combined with the fact that, in many cases the loans are given to buy properties and commercial buildings which are then used as collateral, the banks will suffer an extra loss because of the decreased real estate prices. This suggests that when the banks respond to an increase in capital requirements, they increase their total capital level and (probably) decrease their total loans however for their actual level of riskiness it is ambiguous whether it goes up (in line with the results in Chapter 2) or down. This phenomenon was witnessed in the 2007-2009 financial crisis and it demands for more sophisticated measures for the risk weighted assets from the

regulators and Basel III is heading toward this direction.

Finally, by examining the change in the effect of Gap on loans and capital growth in the before, during and after the crisis periods I find that in the after crisis period greatly increased their growth rate of Tier 1 capital in response to an increase in capital requirements. This suggests that policies designed to encourage banks to increase their capital ratios by enriching them with higher quality and higher loss absorbance capability have been effective, since in the post-crisis period banks placed more emphasis on adjusting capital ratios by raising better-quality, tier 1 capital together rather than focusing, as much on changing their balance sheet risk.

5 Conclusion

In this chapter I examine the effects of bank capitalisation of different types of banks loans, assets and capital growth for the UK commercial banks during 1999-2016. I first estimate the bank's internal target for capital ratio following a partial adjustment method widely spread in the literature. From this estimation I find that the commercial banks in the UK will need on average roughly 2.5 years to adjust their capital ratios to their target ratios. The larger banks with easier access to funding and better diversified portfolio hold smaller capital buffers. Also, the banks with a high share of better quality Tier 1 tend to increase their overall capital ratio in order to avoid the costs of topping up rapidly their capital ratio in case of a negative shock or a regulatory change. I then calculate a measure of capital surplus/deficit (Gap index) which is the distance between the actual capital ratio and the desired one. Figure 2 shows that the worse capitalised banks suffered a significant drop in their Gap index at the start of the financial crisis and they had to extensively adjust their portfolio and/or capital in order to manage to reach their pre-crisis levels of capitalisation (Gap index). At the same time the better capitalised banks managed to maintain their reach their pre-crisis capital surplus a lot quicker.

I then use this Gap index to examine its impact on the different types of bank loans' growth (Commercial, Consumer, Rear estate, Interbank, Other loans and Other assets) and on their capital's growth (Total regulatory capital and Tier 1). I find that when the Gap increases, banks increase their lending for the loans with the higher weight in the RWA (Commercial and Consumer) and decrease

their credit supply of the ones with the lower weight (Real estate, Other assets). This way they increase their risk weighted assets which is lowering their capital ratio. At the same time, the Gap increase brings a fall in the growth of both total and Tier 1 capital growth, reducing further their capital ratio. However, the underlying risk of the mortgage loans, especially during an economic crisis, leaves the effect on the bank's actual risk level ambiguous. The effect of Gap on assets and capital growth has also examined before, during and after the crisis to highlight any differences in the banks approach. I find that during the crisis they adjust their loan portfolio to maintain their risk weighted capital ratio and follow the regulatory instructions, while in the post-crisis period it is the capital (both total and Tier1) that is substantially adjusted in response to Gap changes. It shows the capital's (especially Tier 1) nature during a financial crisis as it becomes more costly to raise and more scarce.

Furthermore, the economic upturn proxied by the GDP growth has a negative effect on capital growth and positive on loans. This means that during an economic downturn the banks will decrease their earning by limiting credit supply and increase their costs by rapidly raising capital. This brings up the possibility for the procyclicality effects of capital requirements since in times of economic turbulence regulators tend to intervene and increase them, adding hurdles to the bank's survival. On the other hand reducing them during an economic crisis would be damaging for their stability. Also, combined with the issue raised earlier about the insufficient measures for the risk weighted assets missing the underlying risks involved with mortgage loans creates an important issue. The only solution is to supervise the banks's risk management during the less distressed times and make

sure that the amount of capital ratio they hold accounts for the true (as much as possible) level of their risk. The regulators seem to be aware of this issue since the Basel III introduces a series of higher countercyclical capital ratios in its latest package reforms. Moreover Provisions for loan losses and Chagre-offs act as a deterrent for loans growth.

The focus of this chapter has been lending to various sectors of the economy and for this reason only commercial banks have been considered. After further restrictions to the sample with criteria about the size of their activities, the availability of data for long periods and whether their focus has been to domestic lending leaves only 16 commercial banks which also limited the estimation techniques' options. This means that the results, even though in their majority are in line with the literature, from this chapter must be used with caution when making generalisations about the banking industry. A final note on this work is that the models I have used, unlike the portfolio theory models, do not examine if the results are consistent with the long-run portfolio theory. Normally in a portfolio theory, even when your desired and the actual position are not the same, the balance sheet constraints must hold at all times and in the long-run each asset might have a different share of the portfolio but their growth rates should be the same as the portfolio's. Otherwise, the assets with the highest growth rate will dominate over the rest. This point is also valid for the rest of the literature that I am following and can be considered as something for future research.

6   Appendix

GMM estimator

As summarised by Roodman (2007), the GMM estimators are general estimators designed for panels with a small number of time periods and a large number of individuals. The specification of the model needs to be a dynamic linear model, the independent variables can be correlated withe the past and current values of the error term (i.e. endogenous). This method also allows the inclusion of fixed individual effects and the existence of heteroskedasticity and autocorrelation within individuals but not across them. Lastly, it assumes that the only available instruments are the lags of the instrumented variables which are assumed to be uncorrelated with the fixed effects which increases efficiency. The GMM estimator is not only efficient but also consistent, meaning that under appropriate conditions it converges in probability to β as sample size reaches infinity (Hansen 1982). The work of Arellano & Bond(1991) who created the Difference GMM combined with the work by Arellano & Bover (1995) and Blundell & Bond(1998) who augment the estimator by adding the efficiency assumption bring the system GMM estimator. It is a linear GMM estimator in a system containing both first-differenced and levels equations. The following derivation of the estimation is shown as found in Roodman (2007). The model that needs to be fitted is:

$$y = x'\beta + \epsilon$$

$$E\left[\epsilon|z\right] = 0$$

where β is a vector of coefficients, y and ϵ are random variables, $x = [x_1...x_k]'$ is a column vector of k regressors, $z = [z_1...z_j]'$ is a column vector of j instruments and x and z may share elements, and $j \geq k$. He uses X, Y, and Z to represent matrices of N observations for x, y, and z, and define $E = Y - X\beta$. The empirical residuals for an estimate $\hat{\beta}$ are $\hat{E} = [\hat{e}_1...\hat{e}_N]' = Y - X\hat{\beta}$. For a vector of empirical moments $E_N[z\epsilon] \equiv \frac{1}{N}Z'\hat{E}$, if a matrix A is a generalized metric, based on a positive semi-definite quadratic form then it is:

$$\parallel E_N[z\epsilon] \parallel_A = \parallel \frac{1}{N}Z'\hat{E} \parallel_A \equiv N(\frac{1}{N}Z'\hat{E})'A(\frac{1}{N}Z'\hat{E}) = \frac{1}{N}\hat{E}'ZAZ'\hat{E}$$

To derive the implied GMM estimator $\hat{\beta}_A$ he solves the minimization problem $\hat{\beta}_A = \arg\min_{\hat{\beta}}$ which results in the GMM estimator:

$$\hat{\beta}_A = (X'ZAZ'X)^{-1}X'ZAZ'Y$$

Chapter 4

Banking competition and stability:

evidence from Western advanced economies

Abstract

The recent financial crisis highlighted the importance of the financial sector and one of the factors that researchers have particularly examined that influences stability is the level of competition in the banking industry. This chapter examines this relationship for Western advanced economies during 2002-2011, using aggregated data on the country level to better examine the industry's overall risk rather than the individual. I find evidence to support the competition-stability theory when using the Boone indicator and the competition-fragility theory when using the Lerner index and the HHI index showing that different measures of competition capture different aspects of it. Also, I document an increased benefit from the present of stronger and more stringent regulation and supervision in the less competitive markets.

1 Introduction

The recent financial crisis highlighted the importance of the financial sector and how fragile it can be without the appropriate supervision and regulatory framework. One of the factors that researchers have particularly examined that influences stability is the level of competition in the banking industry. The competition in the financial sector offers low cost of borrowing which is translated in increased investments, easier access to financial services and more innovation which overall improve welfare economic growth. Its impact on financial stability has attracted great interest over the years from both policymakers and academics. However it still remains unanswered with opposing theoretical and empirical results. The difficulty of finding widely accepted and accurate measures for competition (and stability) have led to case-dependent results based on the measures the are used and their choice of countries.

On the one hand, there is the "competition-fragility" theory that more competition among banks leads to more fragility. Following from the theoretical models by Marcus (1984) and Keeley (1990), the idea behind it is that as competition decreases the bank's franchise value and profit margins are reduced to the point that they will seek more profitable and riskier assets and activities to invest in. On the other hand, the "competiton-stability" view has been introduced primarily by Boyd and De Nicolo

(2005) and Boyd et al. (2006) who followed Stiglitz and Weiss's (1981) model. It explains that in more competitive banking systems where interest rates are low the consumers find it easier to repay their debt limiting the bank's losses and probability of default. However, in the more recent literature(e.g. Martinez-Miera and Repullo (2010), Hakenes and Schnabel (2011)) show that the relationship between competition and risk is non-linear(they find that it is more U-shaped). This means that for some levels competition can be beneficial for the financial stability and for others it has unfavourable results.

This chapter contributes to this literature as I attempt to shed more light on the competition stability nexus by using aggregated data at the country level to offer a different view of the overall stability of the banking system rather than the individual banks. I use two different competition measures (Lerner, Boone), for a period (2002-1011) that includes the financial crisis for the European Union(which has only being examined briefly in the literature using these measures) and four more Western advanced economies (USA,Canada, Switzerland and Norway). The Lerner index shows evidence in favour of the competition-fragility approach. Specifically, higher market power leads to greater stability when controlling for macroeconomic, Banking sector-specific and regulatory variables. The opposite result is derived by the Boone indicator which supports the idea that different competition measures capture different aspects of the

competition and correlate differently with the stability measures even in the same sample (Liu et al. (2012), Kick and Prieto (2015)). This shows that different measures capture a different aspect of competition and can provide different results which is one of the reasons why the literature has not given a clear answer yet.

I also examine the effect of regulation on this competition stability nexus by adding interaction terms of the regulatory variables and the competition measures. I find evidence that the benefit in stability from higher supervisory power and more stringent activity restrictions is greater in a less competitive banking industry, since a strong supervisory presence is necessary in these markets. For robustness tests I, first, use a concentration measure(HHI index) as a proxy for competition which supports the competition-fragility view also found by the Lerner index. Secondly, I examine whether the non-linearity specification is present in my sample including the squared version of the competition measure that I am using in each model, however the results do not support this.

The remainder of this chapter is organised as follows. The relevant theoretical and empirical literature is summarised in Section two. The data and methodology used to analyse the relationship between competition and stability are presented in Section three. The results from the analysis are reported and explained in Section four. Section five concludes.

2 Literature review

After the current financial crisis began, politicians and regulators in the U.S. stated that the low level of competition in the banking sector may have been a significant factor in the crisis and the recovery of the industry. I focus on Western advanced and developing economies which were affected by the crisis (i.e. EU, USA, Canada, Switzerland and Norway) and the studies about them show that, depending on the method and competition measures used, the banking industry can be described as a monopolistic competition. In some cases it can even have an oligopolistic structure. What has been shown is that greater competition in the banking sector could lead to lower costs, greater innovation, efficiency and improvement of the quality of financial services. According to Bikker and Spierdijk (2008), who examined the development of bank competition in the Euro Area, there has been a decrease in bank competition up to the years of the crisis. They explain that is the outcome of the increase in concentration, bank size and off-balance sheet activities. The concentration and the banks' size in the banking sectors of the EU countries continued to increase even during the crisis period.

It has been established that the banking sectors of all EU countries are not homogeneous, however there are similarities within the EU-15 and EU-12 groups. According to Weill (2013), the direction of the changes in

competition between banks within EU-15 countries are ambiguous. For the EU-12 group Pawlowska (2012) and Efthyvoulou and Yildrim (2013) provide evidence of increase in competition before the crisis and a less significant decrease during the crisis. Between EU-15 and EU-12 countries there has been a convergence in competition before the crisis.

There is a substantial literature on the relationship between competition in the banking sector and the financial stability of that country. There is still no academic consensus on whether competition is also responsible for the greater fragility, with conflicted theoretical predictions and mixed empirical results. The evidence also points to a complex relationship between concentration and stability. Based on the theoretical and the empirical literature changes and differences in market structures and competition and their effects on stability are very much case-dependent. As it is presented by Allen and Gale (2000, 2004) different models can provide different results regarding the trade-off between banking competition and stability. They find similarly mixed results about the relationship between risk and the competition level of the market.

2.1 Theoretical literature

As stated before, what comes out of the literature is that the impact of competition on bank risk is ambiguous in both the theoretical and the

empirical literature. On the one hand, enhanced competition could lead to excessive risk-taking by banks (Keeley (1990), Repullo (2004) and Jimenez and Lopez, (2007)). They find, using US data, that increased banking competition combined with deregulation that took place in the US during the 1990s decreased monopoly rents and contributed to bank failures. As explained by Hellman et al. (2000) the increased competition reduces market power which, along with limited liability and the application of flat rate deposit insurance, potentially leads to a more risk-taking behaviour from the banks. Boot and Thakor (1993) and Allen and Gale (2000) argue that in a more competitive environment, since banks earn lower rents, they also reduce their incentives for monitoring.

When using concentration to proxy competition there are reasons to support that competition leads to greater fragility. One characteristic of large banks is that they can diversify better so that banking systems dominated with a few large banks are likely to be more stable than banking systems with a large number of small banks (Allen and Gale, 2004). On top of that, it is argued that a few large banks are easier to monitor and supervise compared to competitive banking systems with a large number of small banks. This theory represents the "charter value" idea.

On the front of the relationship between competition and risk-taking behavior from the banks Boyd and De Niccoló (2005) argue that the above

theory ignores the effect of bank competition on borrowers' behavior and for that reason it is fragile. Boyd and De Niccoló (2005) explain that as concentration increases, banks' market power also increases which they use to charge higher loan rates. Stiglitz and Weiss (1981) show that higher loan rates increase the probability of bankruptcy for borrowers, who in turn will need to take on riskier projects to avoid it. This will make the financial system less stable and increase the probability of a financial crisis.

Moreover, in contrast to the argument that higher concentration will bring more stability, Kane (1989) and Anginer and Warburton (2011), argue that "too-big-to-fail" banks, because of the promise for help in difficult times from the government, have different risk taking incentives which can destabilize the financial system. In addition, Johnson and Kwak (2010) support that very large banks can be very difficult to supervise given their complexity, and their ability to politically capture their supervisors which can lead to systemic risk. Finally, this school of thought recognizes that the first theory might be correct in countries with generous safety nets and weak supervision.

Moving onto the relationship between risk and competition we find that the realisation of risk is a complex and multifaceted phenomenon and there are certain studies that use a number of different risk indica-

tors to gauge the level of distress that banks experienced which can be either systemic risk or bank's individual risk. A large part of the literature has focused on the relationship between competition and the absolute level of risk of individual banks. Anginer et al. (2012) in their analysis, though, examine the correlation in the risk taking behavior of banks, hence systemic risk and they find that greater competition encourages banks to take on more diversified risks, making the banking system less fragile to shocks. Theories based on the idea of 'charter value' argue that market power mitigates bank risk taking, since foregone future profits in the case of bankruptcy are higher. However, more recent theories suggest that stronger competition does not necessarily worsen stability. As regards bank liability side risk, it argues that coordination problems among depositors causing bank fragility can emerge independently of competition. On the asset side risk, it argues that there can be cases in which a concentrated banking sector would be riskier than a competitive sector.

2.2 Empirical literature

As summarized in the ECB paper by Carletti and Hartmann (2002) in the empirical literature, one can distinguish four types of studies: the first type regresses measures of bank risk on measures of bank market power, the second group of papers assesses the potential diversification

or risk reduction effects of combining different businesses in a merger or increasing bank size in other ways, the third type measures changes in bank stock return correlations as an indicator of the implications of consolidation for systemic risk and the fourth type discusses the relative efficiency and risk in bank sectors of different countries that are more or less competitive. The most common measures used for competition are the concentration, Lerner index and the H-statistic and for the stability the Zscore (all are explained in the data and methodology section) and the NPLs (Non-Performing Loans).

In the empirical literature we find evidence from studies which support the influential 'charter-value' hypothesis and from others that support the competition-stability view. As it has been stated earlier, the results on the trade-off between competition and stability from the empirical literature are inconclusive and depend on the different measures used for competition and stability, the method, the number of countries chosen and on whether the dataset used has bank-level or aggregate data. Most of the studies, until recently, either focus on one country or if they use panel data they use bank-level data and focus on the individual risk rather than the systemic risk. Specifically, Anginer et al. (2012), that it is better to use country-level data instead of bank-level data to examine systemic risk rather than individual bank risk.

Early studies like Demsetz, Saidenberg, and Strahan (1996) and Galloway et al. (1997) find results which support Keeley's (1990) theory about the 'charter value'. Jiménez et al. (2007a) examine the effect of banking competition on bank risk-taking in Spain for the period 1988-2003. As a measure of bank risk-taking and financial stability, they use NPLs and the Lerner index is used for competition as well as HHI. They show that the HHI does not affect NPLs and that competition is negatively related to the bank's risk, implying that greater market power is associated with lower level of NPLs.

When concentration is found to be endogenous then more concentrated systems tend to have larger and better-diversified banks. Beck et al. (2006) in a cross-country study, using data for 69 countries for the period l980-1997, show that systemic crises are less likely in concentrated banking systems and that fewer regulatory restrictions are associated with less systemic fragility. Similarly, Berger et al. (2009) in a cross-country study of 23 developed nations show that market power increases loan portfolio risk of banks but decreases overall risk because banks with market power hold more equity capital. Schenk et al. (2009) using the Panzar-Rosse H-statistic to proxy for competition with data for 45 countries between 1980 and 2005 find that concentration itself is associated with a higher probability of a crisis. Beck, De Jonghe, and Schepens (2013) using the Lerner index find a negative relation between competition and stability,

but show that the strength of the relation varies across countries based on country level institutions. This result is similar to the one derived in this chapter as well.

In favour of the alternative hypothesis which states that more competition brings more stability we have De Nicoló, Bartholomew, Zaman, and Zephirin (2004) who find that countries with more concentrated banking systems show higher levels of risk-taking. This is also confirmed by Houston, Lin and Ma (2010) who use the Herfindahl index to proxy for competition. Barth, Lin, and Song (2009) find the same result through a different channel. They show that bank competition reduces corruption in bank lending, which can improve bank stability. Using the ability of banks to pass on cost increases as a measure of competition, Schaeck, Cihak, and Wolfe (2009) also find that more competition reduces risk-taking. They find that countries with more competitive banking systems are less likely to experience a financial crisis. Consistent with the lending rate channel in Boyd and De Nicoló (2005), Garmaise and Moskowitz (2006) find that after banks merge, they charge higher interest rates. Boyd, De Nicoló, and Jalal (2009, 2010) find that when bank competition is higher, the bankruptcy risk of the bank is lower, borrower risk is lower, and the loan-to-asset ratio is higher.

There are fewer studies which use aggregate data, however because of

recent datasets like the Global Financial Development Database (GFDD) their number is rising. For example, in Uhde and Heimeshoff (2009) they examine the effect of banking concentration on financial stability for the period 1997-2005 for the EU-25 countries. It is the first study investigating this relationship using panel data analysis for EU countries. Zscore is the proxy for financial stability. Their results show a negative relationship between concentration and stability. Anginer et al. (2012) investigate the link between competition and risk-taking behaviour of banks. They obtain a sample of publicly traded banks from 63 countries for the period 1997-2009. They focus on systemic risk rather than individual bank risk, in order to address macro-prudential policy issues. Hence, they do not use bank-level data. Instead of the Zscore, an alternative measure is used to address potential spurious correlation between the Lerner Index and Zscore, since both are calculated using profitability measures. The results presented show that higher competition leads banks to a higher level of risk diversification and hence, to greater stability.

Finally, in recent years, because of the changes in regulations after the crisis in Europe and of the availability of better datasets there has been an increasing interest for the effect of regulation on competition and stability. Agoraki et al. (2011) conduct a country-level analysis and for comparison use a panel dataset for 546 banks in 13 countries as well. They find similar results for both approaches using both NPLs and Zscore to proxy

stability and the Lerner Index for competition. The important addition is the one of regulatory variables like capital stringency, supervisory power and restrictions in activities. Results show a negative significant relationship between market power and NPLs. When capital requirements are combined with market power, risk-taking is lower. Official supervisory power is the only mechanism to reduce directly risk. Lastly, in their analysis Anginer et al. (2012) also examine the impact of the institutional and regulatory environment on systemic stability and show that banking systems are more fragile in countries with weak supervision and private monitoring, high government ownership of banks, and in countries with public policies that restrict competition.

3   DATA AND METHODOLOGY

In the empirical literature there have been a large number of measures for banking stability as well as for competition in the banking industry. An even larger number of explanatory and control variable has been used in more or less complex mixes. All the above combined with the various econometric methodologies that the researchers have used have given mixed results and this is one of the reasons why the competition-stability relationship still remains a puzzle. For my research in my regression

model I use a mixture of significant explanatory variables based on previous studies using equally well established regression techniques.

3.1   Data description and Sources

My dataset includes the 28 EU countries and two more European advanced countries which have very similar characteristics Switzerland and Norway and another two Western advanced economies which experienced the financial crisis in a similar way to the EU countries, namely the USA and Canada. The data I am using are annual and aggregated on the country level to give a different view of the competition stability relationship. According to Anginer et al. (2012), when a research aims to assess systemic risk rather than individual bank risk, it is better to use country-level data instead of bank-level data. Moreover, a cross-country analysis is the best approach to address macro-prudential policy issues and facilitate in measuring the impact of institutional and regulatory environment. I use various data sources to construct my sample, specifically the updated World Bank 2013 series, the Global Financial Development Database (GFDD), the World Bank's Worldwide Governance Indicators (WGI), the World Bank Regulation and Supervision Survey (BRSS) and the OECD European Commission's AMECO database. My dataset covers the period 2002-2011 based on the availability of data from the BRSS.

The aforementioned database is unique as it allows us to quantify the level and the quality of regulation and supervision in a country. It is developed by Barth, Caprio and Levine in 2000 (and then updated in 2003, 2005, 2008 and 2011) and includes regulation and supervision data of banks in over 100 countries. They created it based on surveys sent to national bank regulatory and supervisory authorities around the world.

3.1.1   Stability measure

Market-based indicators can be calculated for listed banks and may include volatility of stock returns as a proxy of total risk or indicators of systematic or idiosyncratic risk. Accounting based indicators may include the Zscore, different credit risk indicators (e.g. provisions over total loans, loan loss reserves over loans, impairments to loans, non-performing loans to loans), solvency risk indicators (e.g. equity to total assets, equity to risk-weighted assets), or asset risk (risk-weighted assets to assets). As Zscore captures the overall risk of a bank, it is used as the main risk-taking indicator in this analysis. More specifically, I am using the aggregated Zscore to capture systemic risk potential in banking which can be measured by joint risk-taking of systemically important banks (De Nicoló, Bartholomew, Zaman, and Zephirin, 2004). Consequently, aggregate Zscore can be used as a proxy for systemic risk potential. This indicator

was introduced by Boyd and Graham (1988) who Built on work by Roy (1952) and has been thereafter used in numerous empirical papers (e.g., Boyd et al., 2006; Agoraki et al., 2011; Liu et al., 2013; Samantas, 2013; Schaeck and Cihák, 2014). This Zscore should not be confused with the Altman (1968) Zscore measure, which is a set of financial and economic ratios and it is used to predict corporate finance distress.

Its widespread use is due to its relative simplicity in computation and the fact that it can be computed using publicly available accounting data only. The basic principle of the Zscore measure is to relate a bank's capital level to variability in its returns, so that one can know how much variability in returns can be absorbed by capital without the bank becoming insolvent. The variability in returns is typically measured by the standard deviation of Return on Assets (ROA) as the denominator of Zscore, while the numerator of the ratio is typically defined as the ratio of equity capital to assets plus ROA (on the assumption that those will be available to support the bank remaining in business, or in the case of loss, to adjust the capital level downwards). The assumption is made that a bank becomes insolvent when its capital level falls to zero. Although this assumption is not realistic in practice, as banks need a positive minimum level of capital, there is another potential line of research to identify a minimum level of capital below which a bank cannot operate. Another criticism reported in the literature (e.g. Anginer et al., 2012) spurious correlation might be

present between Lerner and Zscore since they are both using profitability measures to be calculated. This is way I use two more competition measures, to draw safer conclusions about its impact on stability. Lastly, the Zscore is a backward looking measure so it cannot express the market's expectation of a bank's stability in the future. The "distance-to-default" (developed by Merton, 1974) measure is forward looking, measuring the difference between the asset value of the bank and the face value of its debt, scaled by the standard deviation of the bank's asset value. However, it is not available from the GFDD database and the latter does not provide a list of the banks it used to calculate the explanatory variables that I used from it so that I can calculate its aggregated value using the same group of banks.

To approximate the probability that a country's banking system defaults I use the most commonly used *Zscore,* found in Boyd et al. (2006) which is calculated as:

$$Z_{it} = \frac{[ROA_{it} + (E/TA)_{it}]}{(\sigma_{ROA_{it}})}$$

where ROA_{it} is the rate of return on assets, E/TA_{it} is the ratio of equity to assets, and $\sigma_{ROA_{it}}$ is an estimate of the standard deviation of the rate of return on assets. The Zscore indicates with how many standard deviations profits can fall before capital is depleted, so it is the in-

verse of the probability of insolvency (Lepetit and Strobel, 2015). Thus, a higher Zscore indicates that the bank is more stable. As defined in the GFDD dataset the indicator compares the system's buffers (returns and capitalization) with the system's riskiness (volatility of returns). Return of Assets (ROA), equity, and assets are country-level aggregate figures (calculated from underlying bank-by-bank unconsolidated data from Bankscope). To avoid time invariance of the denominator, the standard deviation of ROA is estimated as a 5-year moving average so as to potentially attribute the variation of the Zscore not only to the variation of profitability and capital, but also to the volatility of bank profitability. Additionally, with time the bank's risk profile may change, and so do bank strategy and bank lending pattern. As Zscore is highly skewed, Laeven and Levine (2009) propose to use its natural logarithm (lnZscore), which is normally distributed.

3.1.2 Competition measures

Two of the most frequently used measures for banking competition in the literature are the Lerner index and the H-statistic from the Panzar-Rosse model (1987). The latter assumes long run equilibrium which is unlikely in the case of the crisis period and for this reason I am not using it. My main measure of banking competition is the *Lerner index*, which shows

market power in banking taking into account the competitive behaviour of banks. Higher Lerner Index implies greater market power which means less competition in the banking industry. In the World Bank's 2013 Global Financial Development Database (GFDD) they use bank-level data to calculate the Lerner Index and then they aggregate on the country level to reflect the market power in a country's banking sector. The Lerner index is give by the following:

$$L = \frac{P - MC}{P}$$

where P is the market price set by the bank and MC is its marginal cost.

As a second proxy for the degree of banking competition in the banking sector, which we use for robustness check, we use the Boone (2008) indicator. It is calculated by estimating elasticity of profits and dividing it by marginal costs. Elasticity of profits is estimated by regressing log of return-on-assets on the log of marginal costs. The *Boone Indicator* is based on the theory that in the more competitive environment the more efficient banks enjoy higher profits. This can be seen in a version of the Boone indicator as found in Leuvensteijn et al. (2007):

$$\ln S_i = \alpha + \beta lnmc_i$$

where S_i is the bank's market share and mc_i is the bank's marginal cost. Since the market shares of banks with lower marginal costs are expected to increase, so that β is negative. The stronger competition is, the stronger this effect will be, and the larger, in absolute terms, this (negative) value of β which is the Boone indicator. This implies that a more negative Boone Indicator indicates a higher degree of competition because the reallocation of profits effect is greater.

The last measure used for robustness tests in the *Herfindahl-Hirschman Index (HHI)* which is a measure of market concentration. It is calculated by squaring the market share of each bank as shown below:

$$HHI = \sum_{i=1}^{I} \left(\frac{Deposits_{ci}}{Deposits_c}\right)^2$$

where c is for each country and i is for each bank. Deposits is the total deposits amount of deposits held by all banks in the country c and I is the total number of banks in that country c. The higher the HHI index is the more concentrated the industry is and its values go from 0 to 1. The data for all three variables comes from the GFDD database.

3.1.3 Macroeconomic variables

Following the literature I use as a measure of economic development the natural logarithm of *GDP per capita* measured in constant 2005 US dollars from the World Development Indicators (WDI). To control for the business cycle I use the *GDP growth %* from the World Development Indicators (WDI) which is calculated based on constant 2005 U.S. dollars following Jimenez et al. (2013) and Olivero et al. (2010). Another frequently used macroeconomic variable is the *interest-rate* which is included to control for the monetary environment and it is associated with bank's profitability (Agoraki et al., 2011). I use the short term real interest rate from the OECD European Commission's AMECO database calculated using the nominal short term interest rate divided by the GDP deflator. Finally, I use the *unemployment rate* which will affect the level of banking risk as it will affect the borrowers' income and ability to repay their loans. The data are drawn from the OECD European Commission's AMECO database.

3.1.4 Banking sector-specific variables

As a proxy for moral hazard following Schaeck and Cihak (2008) and Berger et al. (2009) I use the *Bank Capital to total assets (%)* variable.

Capital accounts for the tier 1 capital, other reserves and regulatory capital of a banking sector and it is divided by total financial and non-financial assets. I also include *Net interest income to total income (%)* to control for diversification opportunities, where total income includes net-interest income and non-interest income. I also use *Net interest margin (%)* which is bank's net interest revenue as a share of its average interest-bearing total assets to control for profitability. Finally, I use the *Cost-to-income ratio (%)* as a proxy for cost efficiency which will affect stability of the banking sector. It is defined as the operating expenses of a bank as a share of sum of net-interest revenue and other operating income, the result variable comes after aggregating the data on the country level. The data for all four of these variables are taken from the GFDD dataset.

3.1.5   Regulatory and supervision variables

I use regulation and supervision variables to control for the business environment in each country. Based on the work of Barth et al. (2004, 2005, 2008, 2012) and following many researchers who have used the World Bank's Regulation and Supervision Survey (BRSS) dataset I include the Entry into Banking Requirements index, the Activity restrictions variable, the Capital regulatory index and the Official Supervisory Power index. They are based on a point system and according to whether the

answer to the question in the survey corresponds to a 'yes' or a 'no' they are assigned 1 or 0 points accordingly, they carry the same weight and then they are added up to result a final number. More specifically:

The *Entry into Banking Requirements* shows the degree to which different types of legal submissions are required to obtain a banking license which is influencing the number of banks that can enter in the banking sector. This is making it harder or easier for the theoretically not very stable banks to enter the industry depending on the result of that index. The variable uses eight questions from the survey to create the index and it ranges from zero (low entry barrier) to eight (high entry barrier) based on the aforementioned system.

The *Activity restrictions* variable shows how much banking activities such as securities, insurance and real estate are under constraint. It is a variable that ranges from zero to twelve, with twelve implying the firmest restrictions system on bank activities. The system that the points as assigned are that it gets them based on which one of the four possible answers is given to each question. Namely, Unrestricted=1, Permitted=2, Restricted=3 and Prohibited=4 and then they are added up to give us a number which characterises the level or activity restrictions for that country.

The *Capital regulatory index* measures the level of regulation on bank capital that should be set aside as a cushion for potential market and

credit risks. As it is defined in the BRSS it combines the overall capital stringency, which captures risk elements which are reflected by the capital requirements and the initial capital stringency, which reflects if and to what extent certain regulatory funds are used or should be used officially to initially capitalize a bank. The variable ranges from 0 (no stringency) to 9 (high stringency), by assigning the values of 0 or 1 to the answers 'no' or 'yes' accordingly to nine questions and then adding these values up.

The *Official supervisory power index* quantifies the degree of supervisory power exercised by the supervisory authorities and examines whether they have the authority to intervene in bank managers' decision or even remove them from their position and replace when necessary. It takes the values 0 (low power) to 14 (highest power) based on same system as previously for the selected 14 questions from the survey.

In Table 1 below there is a summary of the statistics of the variables examined in this chapter. One thing to notice is that all three measures of competition imply a moderate level of competition. What is interesting is that the HHI's minimum and maximum values cover almost the entire range of the index showing that the countries in my sample from very competitive industries to almost monopolies. The average Boone indicator is also small (-0.039) and negative which is in line with the theoretical prediction that increase in marginal costs is associated with the loss of

market share. Another thing to notice is that this sample includes very poor and very rich countries as shown from the GDP per capita. Furthermore, since the sample period covers the early stages of the recent financial crisis, the GDP growth goes as low as -14.8% and because it includes both advanced and developing countries the maximum that it reaches is 11.6%. Finally, concerning the regulatory framework in the countries examined here, the relatively high average values of the regulatory variables imply relatively high supervisory power and stringent regulation(since higher values mean more stringent and more restrictive policies).

Table 1: Descriptive statistics					
Variable	Observations	Mean	Standard Deviation	Min	Max
Panel A: Key variables					
lnZscore	319	2.408	0.767	-0.807	3.845
Boone	318	-0.039	0.369	-2.082	5.968
Lerner	312	0.205	0.134	-1.609	0.470
HHI	320	0.192	0.156	0.012	0.978
Panel B: Country-specific variables					
GDP Growth	316	2.195	3.753	-14.814	11.621
Interest rate	311	0.491	2.795	-9.579	25.329
GDP per Capita	320	30576.050	21142.050	2025.316	114119.900
Unemployment	320	7.960	3.712	2.500	21.700
Panel C: Banking sector-specific variables					
Cost to Income	319	58.966	18.815	12.729	226.169
Capital /total assets	306	7.008	2.367	2.700	13.800
Net Interest Income	320	2.335	1.414	0.181	8.894
Non Interest Income	316	39.070	12.824	2.272	79.546
Panel D: Regulatory variables					
Activity Restrictions	317	6.350	1.767	0.000	11.000
Entry Requirements	317	7.473	1.129	0.000	8.000
Capital regulatory index	317	6.107	1.754	3.000	10.000
Supervisory power	317	10.543	2.515	4.000	14.000

3.2   Model and Methodology

In this section I introduce the baseline model that I am using and I explain into more detail the chosen explanatory variables using supporting evidence from the literature.

The model that has been used to examine the relationship between competition and stability is a dynamic partial equilibrium one; the reason for the existence of the lagged Zscore is to capture the expected (Garcia-Marco & Robles-Fernandez (2008), Jimenez et al. (2010) and Ahi and Laidroo (2016)) persistency in bank risk-taking. If persistency is present, it is expected to exhibit a positive association with a the dependent variable (Zscore). As discussed in section 3.1.2, several competition measures are considered in this paper to account for the different approaches found in the literature to measure competition. These are included in the model one by one and their association with z-score is expected to remain ambiguous.

I control for the business cycle by introducing the GDP real growth rate has been used by Jimenez et al. (2013) and Olivero et al. (2010). GDP per capita, is expected to reduce the probability of a bank crisis, which usually follows loan risk during economic recessions. We also need to control for differences in economic conditions by adding the unemployment rate. According to Boyd et al. (2004), when the nominal rate of

interest (inflation) is below a certain threshold, a relatively higher probability of bank failure is present in monopolies since the motivation to lend cash reserves dominates that of paying low rates on deposit accounts.

Capital ratio is the value of total equity deflated by a bank's total assets. We employ it to account for differentials in risk preference behaviour of bank managers along the lines of Schaeck and Cihak (2008) and Berger et al. (2009). Diversification indicates the ability of a bank to expand its operations to off-balance sheet activities, namely to insurance, real estate and securities activities; thus, a standard proxy is the total non-interest operating income over total. I expect a negative association between diversification and risk but it also might be the case that banks with high-income diversification are exposed to greater risks in their attempt to accomplish economies of scope (Stiroh, 2004). Cost efficiency turns out to be the most widely employed accounting variable that proxy for cost efficiency as contemporary efficiency modelling may produce bias due to certain methodological and econometric assumptions. A negative effect on stability is expected since inefficient banks tend to engage in risky behaviour to make up for insufficient performance (Uhde and Heimeshoff, 2009).

Required reserves of capital may constitute sufficient buffers in view of potential liquidity shocks notwithstanding the case of banks embarking

on gambling behaviour in order to make up either for the utility loss of powerful bank owners (Laeven and Levine, 2009). Official supervisory power is expected to show that strong supervision discourages managers to undertake excessive risk. This effect can be especially present in countries with low accounting requirements (Fernandez and Gonzalez, 2005). On the other hand, it may be correlated with corruption in lending transactions, and obstruction of bank operations (Barth et al., 2004). Finally, activity restrictions are theoretically constructed to stop banks to engaging in more risky activities, thus enhance financial stability (Uhde and Heimeshoff, 2009).

The following is the general form of the model that is describing the relationship between the banking competition and the financial stability in a country following the analysis above:

$$\text{Stability}(\ln Z_{it}) = f[\text{Competition}(\ln L_{it}, Boone_{it}, HHI_{it}), \text{Country}(C_{it}),$$

$$\text{Banking sector-specific factors}(B_{it}), \text{Regulatory}(R_{it})] + \epsilon_{it} \tag{1}$$

Equation 2 below shows all the variables used to explain the variation of the financial stability as expressed by the Zscore:

$$
\begin{aligned}
ln(Z_{it}) \;=\; & \alpha + \beta_1 ln(Z_{it-1}) + \beta_2 ln(Competition_{it}) + \beta_3 GDPG_{it} + \beta_4 interest_{it} \quad (2) \\
& + \beta_5 lngdpcap_{it} + \beta_6 unempl_{it} + \beta_7 cost\_to\_income_{it} + \beta_8 capital\_ratio_{it} \\
& + \beta_9 net\_interest\_margin_{it} + \beta_{10} non\_interest\_income_{it} + \beta_{11} entry\_req_{it} \\
& + \beta_{12} capital\_reg_{it} + \beta_{13} super\_power_{it} + \beta_{13} activity\_restr_{it} + e_{it}
\end{aligned}
$$

Where ln(Z) is the natural logarithm of the Z-score for the banking sector of country i at time t; ln (Competition) is either the natural logarithm of the Lerner Index, the Boone index or the HHI index for country i at time t; GDPG is the growth rate of real GDP; interest is the real short-term interest-rates for country i at time t; lngdpercapita is the natural logarithm of the real GDP per capita for country i at time t; unempl is the unemployment rate in country i at time t; cost_to_income is the ratio of costs to total income for banking-sector of country i at time t; ; capital_ratio is the ratio of a country's banking sector equity divided by the banking sector's total assets for country i at time t; net_interest_margin is the banking sector's net interest revenue as a share of its average interest-bearing total assets in country i at time t; non_interest_income is the noninterest income for the banking sector of country i at time t, divided by the total income of the country's banking sector; entry_req stands for entry into banking requirements for the

banks of country i at time t; capital_reg stands for the capital regulatory index of the country i at time t; super_power stands for the official supervisory power index for the country i at time t; activity_restr is the activity restrictions index for the country i at time t.

3.3   Estimation technique

In order to find out what estimation technique to use for my sample and models I first need to check if the lagged dependent variable is significant. From the results in Table 3 and 4 it appears to be highly significant in all the specifications which means that I should be using a dynamic model. This, combined with the fact that I have only 10 periods in my sample and an unbalanced panel, limits the available options.

According to Nickell (1981) the existence of both lagged dependent variables and fixed effects causes a well-known bias. However, Judson and Owen (1999) show that it is better to use standard fixed effects estimation rather than GMM in unbalanced panels when T is large (T>30), the bias declines as the number of time periods increases, and the results of the estimation will be consistent (given there is no autocorrelation of the error terms). Kiviet (1995) argues that the best way to handle dynamic panel bias is to perform LSDV (Least Square Dummy Variable),

then correct the results for the bias, which he finds can be predicted with great precision. However, the approach he advances works only for balanced panels and does not address the potential endogeneity of other regressors. My unbalanced dataset and potential endogeneity from my regressors(Lerner) means that I cannot use the bias correction models available as it violates their assumptions.

I am using the system Generalized Method of Moments (GMM) to estimate my models which is developed by Arellano and Bond (1991) and then improved by Blundell and Bond (1998). This GMM estimator instruments the differenced variables that are not strictly exogenous with all their available lags in levels and variables in levels are instrumented with lags of their own first differences. Under this approach, exogenous variables(regulatory variables), transformed in first differences, are instrumented by themselves, while endogenous regressors (including lagged Zscore and Lerner) are transformed in first differences and instrumented by their lags in levels and all the other control variables are considered predetermined. It ensures efficiency and consistency provided that the models are not subject to serial correlation of order two (Louzis et al. (2012)) and that the instruments used are valid which are tested using the AR(2) and the Sargan/Hansen testing for the validity of instrument subsets, which in all of my regressions is not present.

Finally, according to Arellano and Bond (1991) and Windmeijer (2005) the two-step estimated standard errors have a small-sample downward bias in dynamic panel data setting. Following Roodman (2007), I avoid this by using the Windmeijer (2005) error terms. I restrict the number of lags to two to limit the number of instruments used.

4 Empirical results

In this section I examine the effect that the competition on the banking industry has on that country's financial stability. At this point it is important to remember that the three different measures of competition examine different aspects of the competition. More specifically the Boone indicator connects efficiency with competition, the Lerner measures market power and HHI measures the level of concentration in the industry. It might be the case that severe competition can lead to mergers and acquisitions, which in turn leads to highly concentrated markets.

To see the relationship among the three alternative competition measures used in this sample, in Table 2 we find the Pearson correlations matrix of the variables of main interest used in this analysis (i.e. competition and regulatory variables). What is important to observe is that even though the correlations among the three measures are significant, they are

low which shows exactly that they are measuring competition in a different way. Also, the Boone indicator is low and negative but statistically significantly correlated with the other competition indicators (i.e. Lerner, HHI) which is something that has also been discussed in De Jonghe et.al. (2016). In addition, the Lerner and HHI are negatively correlated with each other and the coefficient is significant which says that the banks in more concentrated countries do not necessarily have more market power. Finally, I included the regulatory variables to see if there is a correlation between competitive markets and regulation. The positive correlation (negative correlation) of the Lerner index (Boone indicator) with the Restrictions, Entry_requirements and Supervisory_power means that less competitive countries have more stringent regulations.

Table 2: Correlation matrix

Variable	Lerner	Boone	HHI	Restrictions	Entry Requirements
Boone	-0.1646 (0.0037)	1			
HHI	-0.1537 (0.0065)	0.1427 (0.0583)	1		
Restrictions	0.0839 (0.0411)	-0.0285 (0.0642)	0.0373 (0.5082)	1	
Entry Requirements	0.0852 (0.0353)	-0.0378 (0.0544)	-0.0139 (0.8055)	0.0087 (0.8776)	1
Supervisory power	0.0799 (0.0612)	-0.0953 (0.0914)	0.0093 (0.8697)	0.1601 (0.0043)	0.0742 (0.1875)

4.1   Competition and stability results

In Table 3, I show the results for my baseline models. The three different groups of control variables are introduced in three steps.   In columns (1) and (2) in the model the country level variables are used as controls variables to focus on the effect of the competition measures on stability. The model used is:

$$\text{Stability}(\ln Z_{it}) = f\left[\text{Competition}(\ln L_{it}, Boone_{it},), \text{Country}(C_{it}),\right] + e_{it}$$

$$(3)$$

In columns (3) and (4) the regulatory variables are introduced to examine their impact on the key variables of this study(i.e. competition). The model used is:

$$\text{Stability}(\ln Z_{it}) = f[\text{Competition}(\ln L_{it}, Boone_{it},), \text{Country}(C_{it}), \quad (4)$$
$$\text{Regulatory}(R_{it})] + e_{it}$$

The last specification includes all four types of variables as described in the model below:

$$\text{Stability}(\ln Z_{it}) = f[\text{Competition}(\ln L_{it}, Boone_{it},), \text{Country}(C_{it}), \quad (5)$$
$$\text{Regulatory}(R_{it}), \text{Banking sector-specific factors}(B_{it})]$$
$$+ e_{it}$$

In all three specifications the lagged dependent variable is highly significant and positive, which shows that previous period's stability is positively influencing the current period's stability. When I use the Lerner index I find that it is positively related to the Zscore suggesting that as the market power of the banks in the industry is increasing so does the financial stability. In other words competition increases bank risk which is

in favour of the "competition-fragility" approach. This prediction is line with idea that, over time, increased competition causes banks to "reach for yield" in an effort to stay profitable (e.g., Becker and Ivashina, 2013). Anginer et al.(2014), however, attribute this co-movement, partly on the fact that both the Zscore and the Lerner index are calculated using bank balance sheet profitability measures.

On the other hand the Boone indicator is negatively impacting the Zscore which means that a higher value of the Boone (less negative values mean lower competition) will decrease the stability of the financial system. This result is in favour of the "competition-stability" nexus. This is the opposite result from the Lerner index, however inconsistencies in results obtained with different competition indicators are not uncommon even within the same sample (e.g. Liu et al., 2012, Kick and Prieto, 2015) since, as explained earlier, the different measures explain different aspects of the competition. The Boone indicator examines it from the efficiency prospective. Since it is based on the idea that the more efficient banks will have higher profits in a competitive environment, the higher the competition the more efficient the banks will become in order to continue to exist, leading to a more stable financial system.

From the banking sector-specific variables Non_Interest_Income and Capital ratio are significant and positive. For the former, the banks by

increasing their income that is not coming from interest earnings (e.g. charges to exchange money) they can limit the activities which are associated with potential risk from the interest earning assets which is contribution to the reduction of their overall risk. On the other hand, Brunnermeier et al. (2011) find that non-interest income is pro-cyclical and is associated with higher systemic risk. For the Capital_ratio the justification is that since better capitalised banks are able to absorb larger loan losses and negative shocks which contributes to the stability of the financial system. As far as the country control variables are concerned, the GDP growth (GDPG) and GDPperCapita have a positive sign(not always significant) in all specifications as expected. Finally the interest_rate is negative and significant (in all specifications apart from the first one) which is showing that high interest rates increase the cost of borrowing which can force the firms to take on riskier projects in order to gain a higher return and compensate for the higher interest rate. It can also be the case that higher interest rates attract "bad borrowers" who are willing to pay the higher premium to get a loan, thus increasing the riskiness of the bank's portfolio.

The consistency of the system GMM estimator depends both on the assumptions that the error term is not auto-correlated as well as on the number and validity of the instruments used. In Tables 3, 4, 5 and 6 three important types of tests are shown. The first test (AR(1) and

AR(2)) examines the hypothesis of no autocorrelation in the error term. The presence of first-order autocorrelation (rejecting the null hypothesis for the AR(1)) in the first difference does not imply that the estimates are inconsistent. However, the presence of second-order autocorrelation (rejecting the null hypothesis for the AR(2)) implies that the estimates are inconsistent. The second one is the Sargan test of over-identifying restrictions. Rejecting the null hypothesis means that the results are weakened by the use of many instruments. The third one is a Hansen test, which examines the validity of the instruments. Rejecting the null hypothesis means that the instruments used are not robust.

In all these tables (3, 4, 5 & 6) the AR(1) test and the Sargan test are rejected and the AR(2) test and Hansen test cannot be rejected at 10% significance level and in most cases at 1% and 5% significance level. These results from the tests do not indicate a reason to question the validity of the instruments used or the consistency of the estimates.

Table 3: Results of the baseline model

VARIABLES	(1) Lerner Equation 3	(2) Boone Equation 3	(3) Lerner Equation 4	(4) Boone Equation 4	(5) Lerner Equation 5	(6) Boone Equation 5
Lag lnZscore	0.726***	0.484***	0.799***	0.576***	0.750***	0.606***
	(0.149)	(0.0834)	(0.0371)	(0.924)	(0.118)	(0.0691)
Competition measure	1.693**	-0.335***	0.399***	-0.356***	0.361*	-0.438***
	(0.807)	(0.0356)	(0.0511)	(0.0791)	(0.213)	(0.0881)
GDPG	0.0198*	0.0156*	0.00800	0.012	0.00242	-0.00701
	(0.0111)	(0.00990)	(0.00520)	(0.01)	(0.00843)	(0.00977)
Interest_rate	-0.0265	-0.0317***	-0.0226***	-0.028**	-0.0188**	-0.0389***
	(0.0198)	(0.0111)	(0.00487)	(0.011)	(0.00701)	(0.00919)
lnGDPperCapita	0.213*	0.161	0.139**	0.129	0.380**	0.331**
	(0.124)	(0.151)	(0.0654)	(0.116)	(0.186)	(0.137)
Restrictions			-0.0132	-0.00327	0.0249	-0.0165
			(0.0147)	(0.0218)	(0.0539)	(0.0294)
Entry_Requirements			-0.0464**	-0.017	0.00686	0.0305
			(0.0178)	(0.046)	(0.0445)	(0.0842)
Supervisory_Power			0.0194**	0.022	0.0510*	0.0463**
			(0.00842)	(0.021)	(0.0276)	(0.0210)
NetInterestMargin					0.132	0.152
					(0.0872)	(0.111)
Non_Interest_Income					0.0129***	0.0100*
					(0.00361)	(0.00499)
Capital ratio					0.0709*	0.0338
					(0.0397)	(0.0491)
Constant	-1.119	-0.416	-0.794	-0.65	-5.392***	-3.983**
	(1.165)	(1.632)	(0.676)	(1.328)	(1.937)	(1.735)
Observations	270	275	267	272	253	258
Number of countries	32	32	32	32	32	32
No of instruments	14	14	19	19	26	26
AR(1)p-value	0.001	0.002	0.001	0.002	0.004	0.005
AR(2)p-value	0.860	0.482	0.792	0.770	0.124	0.874
Sargan test (Pr>chi2)	0.012	0.026	0.000	0.000	0.000	0.000
Hansen test (Pr>chi2)	0.186	0.154	0.255	0.298	0.603	0.100
Prob>F	0.000	0.000	0.000	0.000	0.000	0.000

*Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.10. The system GMM regression estimates with Windmeijer-corrected standard errors are reported of the effect of competition on stability. The dependant variable is the natural logarithm of the Zscore. The Lerner index is used as the Competition measure in columns (1), (3) & (5) and the Boone indicator in columns (2), (4) & (6). Columns (1) & (2) only include the banking sector specific variables specified in Equation 3. Columns (3) & (4) include the banking sector specific variables and the Country specific variables specified in Equation 4. Columns (5) & (6) include the banking sector specific variables, the country specific variables and the regulatory variables specified in Equation 5. The p-value of the Hansen test of validity, the p-value of the Sargan test of over-identifying restrictions and the p-value of the first-order autocorrelation test (AR(1) and AR(2)) are reported. The p-value of the F stat of the equation is shown in the last row.*

4.2   Impact of regulation

In Table 4 below, motivated by the work of Anginer et al. (2012), I examine the impact that the regulation has on the relationship between competition and stability which was found in the analysis above. In order to do that, I use the same model as in columns 3 and 4 in Table 3 augmented by interaction terms between the competition measures and the regulation variables. This can be seen below:

$$\text{Stability}(\ln Z_{it}) \;\; = \;\; f[\text{Competition}(\ln L_{it}, Boone_{it},), \text{Country}(C_{it}), \qquad (6)$$
$$\text{Regulatory}(R_{it}), \text{Banking sector-specific factors}(B_{it})]$$
$$\text{Interaction regulatory terms}(I_{it}) + \epsilon_{it}$$

where the Interaction_regulatory _terms (I_{it}) are the competition variable multiplied by the regulatory variable. In each column only one regulatory variable is introduced along with its interaction term. In columns (1)-(3) the Lerner index is used and for columns (4)-(6) the Boone indicator. The control variables are omitted from the table to allow the key variables to be examined more clearly. From the results we see that the supervisory power interaction term is significant for both competition measures. Specifically, in the case of the Boone estimator the

coefficient of the interaction term is positive which means that the gain in stability from higher supervisory power is greater in less competitive markets. Similarly, the benefit from more stringent activity restrictions is lower for less competitive banking systems. Also, the coefficients of both competition measures change sign in the presence of the significant restrictions interaction term. These results imply that when the policymakers fail to achieve their goal of competition they can compensate by monitoring,intervening better and having more power to impose their authority.

Table 4: Impact of regulatory environment on the competition-stability nexus

VARIABLES	(1) Lerner Restrictions	(2) Lerner Entry	(3) Lerner Power	(4) Boone Restrictions	(5) Boone Entry	(6) Boone Power
L.lnZscore	0.541***	0.622***	0.565***	0.238	0.423***	0.591***
	(0.115)	(0.199)	(0.114)	(0.197)	(0.196)	(0.078)
Competition measure	-4.666*	-1.644	-0.171	1.509**	-3.43*	-1.268***
	(2.621)	(2.683)	(0.124)	(0.552)	(1.82)	(0.353)
Restrictions	-0.164*			-0.082		
	(0.085)			(0.0805)		
Lerner x Restrictions	0.865*					
	(0.437)					
Entry_Requirements		-0.132			0.196	
		(0.118)			(0.178)	
Lerner x Entry_Requirements		0.353				
		(0.436)				
Supervisory_Power			-0.0032			0.040
			(0.063)			(0.033)
Lerner x Supervisory_Power			-0.134*			
			(0.13)			
Boone x Restrictions				-2.556***		
				(0.916)		
Boone x Requirements					0.495	
					(0.296)	
Boone x Supervisory_power						0.145**
						(0.054)
Constant	1.962***	1.675	0.799**	3.403***	0.3	0.599**
	(0.499)	(1.117)	(0.363)	(0.176)	(1.39)	(0.283)
Observations	278	278	278	283	283	283
No of countries	32	32	32	32	32	32
No of instruments	19	19	19	19	19	19
AR(1)p-value	0.002	0.006	0.001	0.045	0.000	0.001
AR(2)p-value	0.319	0.630	0.600	0.332	0.306	0.206
Sargan test(Pr>chi2)	0.039	0.085	0.74	0.000	0.000	0.046
Hansen test(Pr>chi2)	0.495	0.548	0.453	0.110	0.101	0.651
Prob>F	0.000	0.000	0.000	0.000	0.000	0.000

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.10. The system GMM regression estimates with Windmeijer-corrected standard errors are reported of the effect of regulation on the competition-stability nexus. The dependant variable is the natural logarithm of the Zscore. In all columns the specification of Equation 6 is followed. The Lerner index is used as the Competition measure in columns (1)-(3) and the Boone indicator in columns (4)-(6). Activity Restrictions are used in columns (1) & (4); Entry Requirements are used in columns (2) & (5); Supervisory Power are used in columns (3) & (6). The control variables are omitted from the table to allow the key variables to be examined more clearly). The p-value of the Hansen test of validity, the p-value of the Sargan test of over-identifying restrictions and the p-value of the first-order autocorrelation test (AR(1) and AR(2)) are reported. The p-value of the F stat of the equation is shown in the last row.

4.3 Robustness checks

In Table 5 below, the HHI is used as an alternative measure of risk to shed more light in the relationship between competition and stability as the competition measure using in Table 3 (Lerner, Boone) are inconclusive. On thing to notice is that in the literature concentration measures are considered as poor proxies for bank competition (Claessens and Laeven(2004)). In columns (4), (5) and (6) in Table 5, a final robustness test is conducted to examine whether the specification of the model used in Equation 2 is correct, which is done by including the squared version of the various competition measures in the full model in columns (5) and (6) in Table 3. This is testing for non-linearity in the relationship between the competition and stability which would show that for certain levels of competition it is a positive and for the rest it will be negative. None of the squared terms appears to be significant, even though what is interesting is that when introduced to the Boone model they change its coefficient to positive which is line with the "competition-fragility" theory, however it is insignificant.

VARIABLES	(1) HHI Equation 3	(2) HHI Equation 4	(3) HHI Equation 5	(4) Lerner Nonlinearity	(5) Boone Nonlinearity	(6) HHI Nonlinearity
L.lnZscore	0.618***	0.693***	0.584***	0.768***	0.526***	0.400*
	(0.0951)	(0.100)	(0.0816)	(0.150)	(0.139)	(0.234)
Competition measure	-1.510**	-0.643*	-0.639*	0.883**	0.149	3.970
	(0.721)	(0.321)	(0.340)	(0.331)	(0.628)	(2.775)
Competition measure_sq				0.417	0.318	-3.625
				(0.308)	(0.357)	(3.020)
GDPG	0.0365	0.008	0.006	-0.001	0.007	0.00399
	(0.0241)	(0.009)	(0.009)	(0.007)	(0.01)	(0.00903)
Interest_rate	0.0288	-0.023**	-0.028***	-0.0204***	-0.0224***	-0.0152*
	(0.0325)	(0.010)	(0.01)	(0.007)	(0.00697)	(0.00766)
lnGDPperCapita	0.432**	0.199*	0.535***	0.220	0.383**	0.777***
	(0.184)	(0.107)	(0.184)	(0.190)	(0.178)	(0.274)
Restrictions		-0.016	-0.023	0.0105	0.0362	0.0691
		(0.020)	(0.024)	(0.036)	(0.0869)	(0.0717)
Entry_Requirements		-0.06*	-0.010	0.011	0.0805	0.104
		(0.032)	(0.088)	(0.057)	(0.0859)	(0.0688)
Supervisory_Power		0.018	0.055	0.043	0.0494	0.0777*
		(0.022)	(0.037)	(0.027)	(0.0317)	(0.0402)
NetInterestMargin			0.265**	0.073	0.142	0.186
			(0.107)	(0.104)	(0.105)	(0.120)
Non_Interest_Income			0.010*	0.011**	0.0139**	0.0133**
			(0.006)	(0.004)	(0.00522)	(0.00637)
Capital ratio			0.042	0.040	0.0694	0.0824
			(0.047)	(0.053)	(0.0664)	(0.0604)
Constant	-3.829*	-1.693	-6.117**	-3.360	-5.470**	-10.49***
	(1.904)	(1.421)	(2.685)	(2.591)	(2.375)	(3.563)
Observations	276	273	259	253	258	259
Number of countries	32	32	32	32	32	32
No of instruments	14	19	26	26	26	26
AR(1)p-value		0.002	0.004	0.004	0.010	0.024
AR(2)p-value		0.748	0.985	0.147	0.579	0.218
Sargan test (Pr>chi2)		0.045	0.000	0.000	0.000	0.000
Hansen test (Pr>chi2)		0.285	0.252	0.611	0.541	0.588
Prob>F	0.000	0.000	0.000	0.000	0.000	0.000

Table 5: Robustness checks using HHI and the non-linearity approach

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.10. The system GMM regression estimates with Windmeijer-corrected standard errors are reported of the effect of concentration on stability. The dependant variable is the natural logarithm of the Zscore. The HHI index is used as the Competition measure in columns (1)-(3). Column (1) only includes the banking sector specific variables specified in Equation 3. Column (2) includes the banking sector specific variables and the Country specific variables specified in Equation 4. Column (3) includes the banking sector specific variables, the country specific variables and the regulatory variables specified in Equation 5. The squared competition variable is introduced in in columns (4)-(6) to test the non-linearity condition using the specification found in the model (5). The Lerner index is used as the Competition measure in column (4), the Boone indicator in column (5) and the HHI index in column (6). The p-value of the Hansen test of validity, the p-value of the Sargan test of over-identifying restrictions and the p-value of the first-order autocorrelation test (AR(1) and AR(2)) are reported. The p-value of the F stat of the equation is shown in the last row.

5 Conclusion

A mistake that is very common in the literature (especially in the early studies) is that all the measures of concentration and competition that have been used are interpreted as competition. In truth, competition is not observable and it is very difficult to measure. Thus, so far, there have only being proxies, with sometimes underlying assumptions which are difficult to be satisfied in most cases, that are focusing on different parts of the competition (e.g. price, quantity, quality). This means that we, especially the policymakers, need to be careful how we interpret the results found in studies in this literature.

One of the policymakers and supervisors' tasks is to monitor (and intervene when necessary) the level of competition in the banking market in order to assist financial stability. In this chapter, I attempted to shed some light on the important subject of competition and stability while examining the contribution of the regulatory framework. I use aggregated data at the country level for the western advanced economies (EU, Switzerland, Norway, USA, Canada). I find that higher market power and concentration lead to higher stability which implies that the benefit of supervising and regulating less banks is higher than the cost of having more systemically important banks ("too big to fail").

On the other hand, my third measure of competition (Boone), which shows that more effective banks get a higher market share in a competitive environment, offers evidence for the "competition-stability" theory. This means that the negative impact of the competition, which is small profit margins pushing the banks to riskier activities to increase their earning, is outweighed by the ability of more efficient banks to better diversify. Furthermore, I find evidence of an increase in the beneficial effects of higher supervisory power and more stringent activity restrictions on financial stability in the less competitive markets. Finally, the results do not support the idea expressed in late studies that, in some countries, the relationship between competition and stability is not linear.

These results are useful for policymakers who need to make decisions and ensure stability in a number of countries simultaneously like for the European Central Bank or the Basel Committee. They will primarily be interested in how the representative bank reacts to changes in regulation and competition to help them achieve on average their targets (stability and growth). However, the results derived using aggregated data for some of the variables by give misleading results for the policymakers of individuals countries. For example, the Lerner Index which is showing the market power of the bank, when aggregated might produce a relatively small value which would suggest a high level of competition in the industry. It might be the case, though, that very few banks in that country

have very high market power while each one of all the others one are much less powerful even if they are not much smaller banks.

Appendix

Table 6 presents the results from the estimation of regressing the complete model for the various competition measures. The dependent variable in these models remains lnZscore and additional control variables are added which are explained in the model and methodology section under Equation 2. In this version of the model, it still shows that it should examined as a dynamic specification as the lagged Zscore is highly significant and robust in all cases. Also, the competition measures remain significant with the same signs (positive Lerner and HHI and negative Boone). Finally, the interest_rate, the Non_Interest Income and the Capital ratio remain significant and have the expected signs. However, because of the number of regressors and instruments has increased so much for my sample, there is a decrease in the p-value of the Hansen test and many of the variables are becoming insignificant since it is losing degrees of freedom from the addition of the, previously omitted, insignificant regressors.

	(1)	(2)	(3)
	Table 6: Equation 2 specification		
VARIABLES	Lerner	Boone	HHI
	Equation 2	Equation 2	Equation 2
L.lnZscore	0.608***	0.456***	0.533***
	(0.193)	(0.104)	(0.081)
Competition measure	0.501***	-0.342***	0.0439*
	(0.139)	(0.103)	(0.04)
GDPG	0.00117	0.00031	0.0113
	(0.011)	(0.0106)	(0.011)
interest_rate	-0.0211**	-0.0341***	-0.0182**
	(0.0102)	(0.0083)	(0.0075)
lnCapita	0.379	0.258	0.376*
	(0.246)	(0.266)	(0.197)
Restrictions	-0.024	0.0064	-0.0235
	(0.0421)	(0.0545)	(0.0265)
Entry_Requirements	-0.0458	0.0076	-0.0031
	(0.0592)	(0.0401)	(0.0441)
Supervisory_Power	-0.018	-0.0004	-0.0166
	(0.033)	(0.0265)	(0.0259)
Net Interest Margin	0.159	0.0980	0.134
	(0.141)	(0.152)	(0.103)
Non_Income	0.0115***	0.0106**	0.0104*
	(0.0033)	(0.0049)	(0.0057)
Capital ratio	0.127*	0.0635	0.115*
	(0.0653)	(0.0834)	(0.066)
Unemployment	0.0008	-0.0064	-0.0129
	(0.0210)	(0.0271)	(0.015)
Capital_regulatory	0.0047	0.009	0.0224
	(0.025)	(0.033)	(0.0195)
Constant	-4.028	-2.525	-3.878
	(2.862)	(3.136)	(2.401)
Observations	253	258	259
No of countries	32	32	32
No of instruments	30	30	30
AR(1) p-value	0.013	0.004	0.005
AR(2) p-value	0.482	0.848	0.755
Sargan (pr>chi2)	0.001	0.077	0.002
Hansen(pr>chi2)	0.169	0.126	0.263
Prob>F	0.000	0.000	0.000

*Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.10. The system GMM regression estimates with Windmeijer-corrected standard errors are reported of the effect of competition on stability using the specification in Equation 2. The dependant variable is the natural logarithm of the Zscore. The Lerner index is used in column (1), the Boone indicator in column (2) and the HHI index in column (3) as the Competition measure. The p-value of the Hansen test of validity, the p-value of the Sargan test of over-identifying restrictions and the p-value of the first-order autocorrelation test (AR(1) and AR(2)) are reported. The p-value of the F stat of the equation is shown in the last row.*

Chapter 5 Conclusion

The capital requirements have been used the last decades as one of the main instruments for supervision and intervention in the banking industry. The recent financial crisis has highlighted that this policy has not been adequate and that it allowed enough room for the banks to exploit it and maximise their profits without considering the consequences and without been held accountable for their choices. On the contrary they were bailed out when necessary and were granted large amounts on money to assist them with their recapitalisation. This unravelled the lack of supervision and appropriate regulatory framework to deal with "too big to fail" banks, the ineffective measure of risk weighted assets (RWA) and the level of interdependence in the financial sectors across the countries. Also, the high quality capital held by the banks was insufficient to absorb negative shocks and externalities from other financial institutions. The results found in this thesis will need to be re-examined after the complete implementation of the Basel III framework as it can bring a structural change in bank behaviour.

This thesis has attempted to answer questions about the effect of current regulation and competition policies on the bank's behaviour, economic growth and financial stability. In Chapter 2, I built a theoretical framework to investigate how a representative bank adjusts its risk and

capital management strategy in response to changes in minimum capital requirements. I identify two main indirect effects coming from the change in regulation on the bank's behaviour. The first one is the *profitability effect* coming from the more profitable return of the risky asset compared to the capital (safer asset), and the *insurance effect* coming from the bank's need to secure against risk. For sufficiently low levels of risk, the profitability effect dominates and the bank views capital and risk as utility substitutes. In the case of sufficiently large levels of risk the insurance effect dominates and the bank views them as complements. The evidence from the quantitative analysis shows that for the UK banks the latter case holds implying a co-movement of risk and capital. This raises issues about the overall stability of the bank after an increase in capital requirements and the policymakers should consider the optimal risk and capital response lines' sensitivity to this change before implementing any policy.

Furthermore, since the results depend on parameters (which might depend on the state of the economy), the result that I find of potential backfire which should be considered as a recommendation to the policymakers to be cautious rather than anything stronger. A general equilibrium model, for example, could result in a rigid set of instructions to the policymakers. What can be said, however is that the parameters (volatility and expected value of return and the absolute risk aversion coefficient)

used in this model can be of interest for the policymakers as they seem to affect the bank's risk behaviour. Intuitively, an explanation as to why the parameters used for the UK banks bring the potential backfire is that, in such concentrated market, banks might believe they are "too big to fail" and when they increase their capital they also increase their level of risk as they are expecting a bailout safety net. Taken that into account, the policymakers by increased the capital requirements and removing the implied promise of the safety net might change the way the banks risk taking behaviour. This regime is implicit in this model as it does not include bailouts. This static partial equilibrium model offers some significant insights into the bank's risk behaviour without the complexity of a dynamic model. Having said that, the latter could be more informative, after analysing the game between the bank and the regulator, about the actions the regulator should take given the bank's responses.

In Chapter 3 I investigate the impact of capital surplus/deficit on the bank's loan portfolio and asset management for the case of the UK commercial banks. Following an increase in capital requirements, I find evidence of an increase in loans that have less weight according to the risk weighted assets approach along with an increase in capital and a decrease in the ones which carry more weight. However, I explain that there are other risks involved(not captured by the RWA) with mortgage loans (especially for commercial buildings) during an economic crisis because of their

diminishing value of the collateral. This shows the level of inefficiency of the risk weighted assets in its current state. Also, I find a negative relationship between capital and economic growth raising the question about the procyclicality effects of capital requirements. The Basel Committee seems to be aware of these issues as in Basel III higher countercyclical capital ratio, along with changes in the risk weighting system will be introduced shortly in the banking industry. There is also the problem of the tendency of the UK banks to first raise lower quality capital to meet increased capital requirements rather than the higher quality Tier 1 capital which is better at absorbing loan losses and negative externalities.

The policy implications from Chapter 3 can be extended when considering the pre/post crisis analysis. The banks appear to focus on adjusting their portfolio more intensively during the period of the financial crisis than they did before it because it is expensive to raise capital quickly during the financial crisis. Policy makers need to be aware of the contradiction of imposing higher capital requirements along with exhorting the banks to lend to businesses and aid the recovery. Another point to be made is that this study by focusing on the composition of the loan portfolio and not on the total loans shows that a change in capital requirements affects the different types of loans differently. Knowing that banks adjust their loan portfolio following the risk weights instructions for calculating the RWA, the policymakers can change the risk weights to target the part

of the economy that they want to support at that point in time. A financial crisis is a special case and innovative solutions should be applied. For future research, it can be considered the case that the effects examined here will affect the business cycle, since the banks examined here as large banks, which could then feedback into the model. This could be done by using a macro model which would take the effect of Gap on loans, to the macro economy, which in turn would change the GDP growth.

In Chapter 4 I examine the competition-stability nexus in advanced Western economies using aggregated data on the country level to focus on the overall risk of the industry. I use three different proxies for competition and I find evidence to support both the competition-stability and the competition-fragility theory depending on which proxy I use. Higher market power (Lerner index) and concentration (HHI index) increase overall stability supporting the theory of fewer banks becoming easier for the policymakers to supervise and regulate. On the other hand, more competition (Boone estimator) will make the banks more efficient and better diversified in order to survive, promoting stability. The three measures of competition have small correlation among them justifying the idea that different competition proxies capture different aspects of the competition and correlate differently with the stability measures even in the same sample (Liu et al. (2012), Kick and Prieto (2015)). Also the analysis yields a higher benefit in stability from higher supervisory power and

more stringent activity restrictions in less competitive markets.

It is clear from the literature that the answer to the question if more or less competition is better for stability is very case dependent. The issue of proxing competition accurately still remains, so the regulators should use various competition and stability proxies to get robust results for the financial sector that they are regulating which can be different from country to country. One thing for the policymakers to consider is that a market might be highly concentrated but very competitive without any entry barriers. That case is when the banks operate with very low profit margins which can act as a strong deterrent to any other banks which want to enter. This is the case of the UK, since there are no regulations against entry however banking is a highly concentrated market because the competition level is high. The study examined in Chapter 4 uses a reduced form partial equilibrium model, however for the case of the UK (since this chapter and the literature suggest that the results are case dependent) it could be expanded into a wider macro model with threat of entry.

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