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Determinants of Bank Capital and Credit to the Economy: Do Banks not Grant Credit Because they have Shortage of Capital? Evidence for Portugal

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October, 2021

BUSINESS
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Department of Economics

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Acknowledgements

I would first like to thank my mother, my sister, my boyfriend and the rest of my family for the constant encouragement and unconditional support during the last year.

A special thank you to my father, my biggest role model, who always believed in me even when I didn't believe in myself. Wish you were here to see me accomplish this milestone but I'm sure you are watching down on me and guiding me through life. Hope I made you proud.

To my supervisor professor Sérgio Lagoa who promptly accepted my request to help me with my master thesis, thank you for all the support, dedication and availability throughout the whole process.

Lasty I would like to thank the Banco de Portugal Microdata Research Laboratory for providing the necessary data on the Portuguese banking system and for always being so very cooperative.

Resumo

A presente tese tem como objetivo identificar os fatores determinantes nos níveis de risco e capital dos bancos portugueses. Com base em literatura previa desenvolvida por Shrieves & Dahl (1992), Rime (2001) e Heid (2004), estimamos um modelo de equações simultâneas com ajustes parciais para o capital e o risco. As variações do capital e risco são um resultado do comportamento interno dos bancos e de choques exógenos. Com base nos dados de painel dos bancos portugueses de 2008 a 2019, analisamos através do estimador de Arelleno-Bond e de 3SLS que fatores contribuem para os níveis de capital e risco dos bancos.

Os resultados indicam-nos que a dimensão do banco tem um impacto significativo no capital e no risco. Também a pressão exercida pelos reguladores tem um impacto positivo, como era esperado na nos níveis de capital, esta conclusão vai de encontro com a *buffer theory* que defende que bancos com baixos níveis de capital tendem a aumentá-lo, enquanto os bancos com uma almofada elevada de capital tendem a mantê-la para evitar entrarem em incumprimento e sofrer sanções das entidades reguladoras. De 2017 a 2019 é possível observar um aumento de capital transversal a todos os bancos, isto pode-se dever ao fato de terem sido implementadas as últimas alterações do Acordo de Basileia III aliado a um clima económico favorável. Podemos afirmar que os níveis de capital têm um ajusto rápido, comparando com os níveis de capital do período anterior, algo que não se verifica com o risco.

Palavras-Chave: Rácio de Capital, Níveis de Risco, Regulação Bancária, Data de Painel

Classificação JEL: G21, G28, C32

Abstract

The purpose of the present thesis is to assess the determinants of the Portuguese bank's capital ratio and risk level. To do so, and based on previous papers developed by Shrieves & Dahl (1992), Rime (2001) e Heid (2004), we estimate a simultaneous equations model with partial adjustments for capital and risk. The observed changes in capital and risk are a product of discretionary behaviour of the banks and exogenous shocks. By building a panel-data of the Portuguese banks between 2008 and 2019, we examine though the Arellano Bond estimator and the 3SLS estimator the factors contributing to the bank's capital and risk levels.

Our main results indicate that the banks' size has a significant impact on both capital and risk level. Moreover, the regulatory pressure has an expected positive impact when determining the banks' capital ratio, in-line with the buffer theory meaning banks with a low buffer tend to raise their capital levels and banks with a higher capital buffer tend to maintain it to avoid breaching regulation and facing sanctions from regulatory authorizes. From 2017 to 2019 there is a significant increase in capital levels transversal to all banks, that may be related to the final implementation of Basel III Accord combined with a positive economic climate. We also are able to say that capital levels adjust very quickly with regard to capital levels from the previous period, however risk does not.

Keywords: Capital Ratios, Risk Levels, Bank Regulation, Panel Data

JEL Classification: G21, G28, C32

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1. Introduction

Ensuring the financial stability of the banking institutions is an essential factor for the well-functioning of the entire economic system. As a consequence of this vital importance and despite the tendency of the last decades of market deregulation, banking remains one of the most regulated sectors. One of the main tools used to supervise and regulate banks is the minimum capital requirements. These capital requirements are a way to guarantee that the banks hold an acceptable level of capital to ensure that the risk of insolvency is minimized. According to Jackson (2002) the three main reasons banks need supervision are due to: a) the potential negative externalities linked to bank failure and the risk of spreading to other institutions, b) the asymmetry of information between banks and creditors and c) possibility of moral hazard behaviour.

Analysing the determinants of Portuguese banks' capital and credit to the economy helps us better understand the impact regulation has when defining internal capital buffers and how other factors play a role on the amount of money banks choose to hold and the amount of risk they are willing to take in their operations. After reviewing existing literature, we found more studies on this issue concerning the United States and only few papers focused on European countries, more specifically Switzerland, Germany and the United Kingdom. Knowledge on the relationship, both in theoretical and empirical terms, of banks' capital and their risk-taking conduct is still very limited and for that reason we thought that analysing the Portuguese reality would be an important contribution to the literature by providing further empirical evidence on bank capital behaviour in European countries. This paper attempts to contribute to the literature by providing empirical evidence for the Portuguese banks between 2008 and 2019.

In respect to methodology, in this paper we will be using the simultaneous equation model developed by Shrieves and Dahl (1992) so it is possible to analyse the adjustments made by the Portuguese banks both to capital and risk. It is important to point out that using this methodology allows us to acknowledge the exogenous aspect of risk and capital as well as the endogenous. In addition to Shrieves and Dahl's study, Rime's paper on Switzerland's case was also very important for the development of this paper serving as a reference in terms of defining variables and overall guidance.

This paper proceeds as follows. On section 2 we present the literature review, where we can find the main theories concerning banks' behaviour, the impact of the regulatory pressure on the bank's capital buffer, the moral hazard theory and the charter value theory. Section 3, presents a brief institutional setting that provides context of the Portuguese banking

sector and the impact of the 2007-09 financial crisis in terms of regulation and banks supervision. In section 4 we present the empirical model develop by Shrives and Dahl (1992) with some adjustments, define the variables and specify the empirical model. On section 5 we describe the data, apply the model and show the results of the regressions. Section 6 concludes.

2. Literature Review

Although there is no unanimity on the best way to regulate banks, the banking sector is one of the most regulated industries in the world. According to Jackson (2002) there are three main points that justify the need for regulation that demand banks to hold an appropriate amount of capital so that the risk of insolvency is minimized. Firstly, due to the potential negative extremities that result from bank failures resulting from the risk of contagion to other banks and the importance of the role banks play in the real economy and in the payment system. Secondly, the asymmetry of information between the market, the depositors and the institutions that is drastically reduced with adequate supervision and regulation. Lastly, potential for moral hazard behaviour by limited liability stockholders, accentuated by the existence of deposit insurance and by the lender of last resort function of central banks.

Regulation is essential in this particular sector due to the extreme importance of maintaining financial stability and correcting market failures (Santos, 2005). The banking system is extremely vulnerable to fraud, making regulation necessary to protect the clients' interests due to the fact that there is almost no monitorization of the bank from the depositors. Banks have little motivation to hold low amounts of capital due to profitability and to the fact that conceding bad quality credit is easy in the short-run. Given the recent banking crises the urge to supervise and regulate banking activity has increased drastically, not only from the regulators and supervisory authorities but from the banks and their shareholders (Lindquist, 2004) to avoid the risk of a deposit run and the impact that may have on the banking system. During the 2007-09 crisis, banks' core capital was unable to cover the impairments losses from loans and security portfolios. With the intention of reducing risk exposure and avoid similar situation in the future, Basel III was implemented (Bank for International Settlements, 2010).

The 2007 ECB Financial Stability Review (ECB, 2008), indicates us that banks tend to operate above the minimum capital ratio with an additional time-varying capital buffer, these two amounts together form the banks' internal target capital. The time-varying capital buffer's main role is to cope with capital shortfall. Banks can increase their capital ratio by increasing capital, which is costly, or by adapting the security portfolio, reducing risk and retiring credit to the economy. Due to the fact that increasing capital is more costly for the banks, it is expected that the adjustments that need to be done will influence negatively the supply of credit to the economy and consequently leading to adverse effects on the economic activity (Maurin & Toivanen, 2012). Authors also demonstrate that to increase capital, banks reduce credit supply to the economy instead of increasing their CET1 capital. This has major negative consequences of lending to the corporate sector (Giuseppe et al., 2019).

Banks tend to operate above the minimum regulatory capital requirement and hold excess capital so that they minimize the probability of falling under the regulatory minimum capital ratio (Lindquist, 2004), especially if their capital ratio is very volatile. If a bank falls under the legal capital requirements, it not only wouldn't be able to react immediately, but also it would be subject to penalties and in the worst-case scenario be forced to close (Rime, 2001). As a result, there is pressure from markets and regulators to ensure the banks hold more capital than what is legally required.

Lindquist (2004) suggests that poorly capitalized banks run the risk of losing market confidence and reputation, therefore the excess capital buffer acts as an insurance in order to reduce the risk of violating the regulatory minimum capital requirement.

Minimum capital requirements is an essential instrument in banking regulation offering not only a safety net to tackle external economic condition that may occur and as a mechanism for preventing excessive risk-taking (Jokipii & Milne, 2011). Rime (2001) considers that capital regulation is "motivated principally by the concern that a bank may hold less capital than is socially optimal relative to its riskiness as negative externalities resulting from bank default are not reflected in the market capital requirements".

When choosing the appropriate level of capital ratio to maintain, banks' face a hard decision because if on one hand there is the, previously mention, legal minimum capital requirements imposed by rating agencies and regulatory authorities on the other hands in order to meet the investors' expectations they are expect to maximize their return on capital. To analyse this dynamic, Memmel & Raupach (2010) use monthly data from large German banks and studied the target level and the adjustment speed of the capital ratio for each of these banks through a partial-adjustment model. Using a higher time frequency (monthly data instead of yearly) allowed the authors to estimate each bank's adjustment rate separately.The main conclusions of this study indicates that the most effective way for banks to adjust the regulatory capital ratio is on the liability side dominate if the focus is on their relative impact on the overall adjustment rate. However, doing it thru buying/selling assets or changing their riskiness turns out to be quicker approach, which means that the banks' will and capacity to take on credit and market risks changes faster than liabilities are rearranged.

One of the other conclusions of this paper is linked to the motivation behind adjusting capital ratios and not only the ability to do so. Memmel & Raupach (2010) concludes that private commercial banks and banks with a high level of proprietary trading are more likely to adjust the capital ratio than banks of the public sector. This means that banks with a strong orientation towards shareholder value are expected to maintain their capital ratio in a rather narrow interval. This stems from the fact that information asymmetries induce a preference

order from internal capital via debt-to-equity financing, internal capital and equity have its own impairments and lastly because the transaction costs from raising equity are meaningfully larger than from raising public debt. In summary, private banks find more motivation to keep their capital ratio range narrow compared to public banks that have implicit state guarantees and maximizing profit is nor their main business goal, concluding that for German banks' regulatory pressure carries out a significant role in the capital ratio levels.

We can also acknowledge that the existence of capital requirements is also caused by the assumption of a moral hazard behaviour of banks. The consequences of capital requirements on the bank's willingness to risk is dominated by the theory of moral hazard, "in which information asymmetries and deposit insurance shield banks from the disciplining control of depositors" (Jokipii & Milne, 2011). These requirements set by the regulators, can in fact reduce these moral hazards, Rime (2001) mentions in his paper that this forced banks shareholders to absorb part of the losses, resulting in a reduction of value of the deposits insurance out option. Given the above we can state that with less risk and more capital the result is a decrease in bank's default probability. We can also point out that the so called too big to fail banks have an implicit guarantee and tend to preform risker operations. Taking into consideration the bank's size, Liu (2020) concludes that larger banks benefit from economies of scale in screening and monitoring activities that result in a larger scale of operations and a better diversification that might reduce marginal costs due to liquidity risk and credit risk. However, this can also lead to a more risk-taking behaviour that can culminate in higher costs. Larger banks normally have higher probability of having assistance from the authorities if they encounter any type of financial difficulties, this results from the fact that when a larger bank fails it may negatively impact the whole banking system. Given the above, we can conclude that for larger banks it is more beneficial to issue capital or debt on demand regularly rather than holding on to a larger capital buffer (Boucinha & Ribeiro, 2007).

Another interesting factor to analyse is the bank's ownership (whether it's government owned or not) and its connection to the bank's behaviour in terms of target capital ratios and their adjustment speeds. In terms of government's participation in banks, Chunxia Jiang (2019) identifies two main views. The first one, the "development view" (Gerschenkron, 1962) considers that government-owned banks apply resources "toward strategic and socially desirable long-term projects to foster growth". Secondly the political view (Shleifer & Vishny, 1994) that defends that government-owned banks tend to finance projects that may not be efficient but merely politically desirable projects that may translate in votes, political contributions and bribes. According to these two views, it would make sense that government-owned banks would hold higher capital buffers than private banks.

Chunxia Jiang's (2019) paper on the Chinese banking system reality from 2006-2015 studies the effect that government ownership may have on the banks' capital and on the speed of adjustment towards the target capital ratio. After analysing the conclusions of this particular study, we can state that government ownership of the banks has an influence on the banks' target capital ratios, their strategies and their adjustment speeds. Their findings were in line with the "development/political" view of government ownership in banks meaning that private banks do hold a lower target capital compared with government-owned banks and that government-owned banks adjustment speed is faster. Furthermore, the study reviles that the banks owned by the central government (CGOBs) have similar target levels as private banks, however if compared with local government (LGOBs) and state-owned enterprises (SEOBs) the levels are considerably lower. This is probably due to implied government assist and more regulatory tolerance.

In addition to the moral hazard, the bank's size and its type of ownership, another theory present in the literature is the charter value theory. The charter value theory claims that the bank has something to lose if it goes bankrupts because it represents a loss of future profits. The charter value is "the value that is lost as a dead-weight loss on closure of a bank, which would not be lost if the bank is left open" (Acharya, 1996).

Jokipii (2011) argues that contrarily to the prediction of the moral hazard theory banks have their own internal target level of capitalization and no longer hold only the minimum allowable amount of capital. As a result, if this internal target level surpasses the regulatory requirements, there is no longer a relationship between capital and risk taking, even though it is unclear in the literature, this may result from higher risk may increase the probability of default and by consequence motivate the bank to increase their capital or that a higher systematic risk can reduce charter value and lower capital holdings. This means that if the banks internal target is higher than the minimum requirement even if the banks have a reduction in their capital level it will still be above the minimum allowable amount of capital demanded by the regulators, this means that the banks ultimately have no incentive to reduce their systematic risk supporting the argument above mention that there is no relationship between capital and risk taking when the internal target level surpasses the regulatory requirements.

By contrast if the minimum capital requirement happens to exceed the bank's own internal target level, then a higher degree of capitalization will lead to a reduction in risk appetite by which the charter effects become less important.

Within the charter value theory, there has been identified in recent studies the capital buffer theory, it is a "dynamic version of the charter value models in which there are costs both

of altering the level of capital and allowing capital to fall below the minimum required levels" (Jokipii & Milne, 2011). This theory forecasts that the bank will maintain a level of capital above the capital buffer required by the regulators and supervising authorities.

Inside the capital buffer theory framework, Jokipii & Milne (2011) sets apart the long-term and the short-term relationship between capital and risk taking and the impact of regulatory capital from observed capital. In the long-term the relationship between capital and risk can either be negative or positive which is similar to what we can observe in the charter value theory. One the other hand, the short-term relationship will depend essentially on the bank's degree of capitalization. We can expect a positive relationship in the cases of high capitalized banks, on the contrary banks that are moving closer towards the minimum regulatory capital buffer, the relationship is projected to be negative (we explain below the reasons for this). Consequently, an increase in the regulatory required capital will trigger, in the short-term, a reducing of the buffer of capital meaning it will have the same impact as a direct reduction in the capital buffer. In this paper, Jokipii & Milne (2011) creates and unbalanced panel composed by US commercial bank and publicly traded US bank holding companies (BHCs) balance-sheet data from 1986 and 2008. To research the short-run relationship between capital buffer and risk adjustments they assume banks will manage their capital buffer by accounting primarily for the risk of default, in addition to that "risk taking will depend on how close the capital buffer is to the minimum requirement." Further the framework applied took into consideration observed changes in the banks' buffer and their portfolio risk.

Their estimations show that the management of short-term adjustments in capital and risk are dependent on the size of the buffer. This means that if the bank's capital buffer is moving closer to the minimum requirements imposed by the regulators, the relationship between adjustments in capital and risk are negative. Given the above, we can conclude that poorly capitalized banks are forced to have larger buffers by reducing their risk or try to rebuild their buffers by gambling for "resurrection by taking more risk". Alternatively, the positive relationship between capital and risk adjustments that is found in the cases of high capitalized banks, demonstrates that they preserve their internal target level of capital by increasing (*decreasing*) risk when capital increases (*decreases*).

Heid's et al. (2004) paper analyses the reality of a set of German banks over the period of 1994 to 2002 using an altered version of the model developed by Shrieves and Dahl (1992), formed by two simultaneous equations. The two equations of the model explain capital and risk and model the observed "changes in capital and risk as the sum of two respective components, a discretionary component and an exogenous random shock" (Heid et al., 2004). If we look into his analysis, we can say that the conclusions are in line with the capital buffer

theory mentioned above. Banks with high capital buffers, maintain their capital buffer by increasing risk when capital increases. On the contrary banks that find themselves with low capital buffers, attempt to rebuild their target buffer by raising capital and lowering risk. There are policy implications that can result from the relationship between risk and capital. The banks willingness to risk is reduced when there is a more risk sensitive capital regulation in place.

To sum up everything that has been stated so far, the buffer theory states that banks do hold an excess amount of capital above the minimum requirements to reduce the probability of breaching the minimum capital requirements set by the regulators, therefore the banks that have a higher capital buffer are expected to maintain their capital buffers and in the other hand banks with low capital buffers are expected to attempt to rebuild a conformable capital buffer (Heid et al., 2004).

Boucinha and Ribeiro (2007) paper enlightens us on the Portuguese reality concerning banks' capital buffers. Prior to the mid-1980s, Portugal's banking system regulation fell upon the State's responsibility. The Portuguese state had in place a strong regulation of the banking sector with credit limits, restrictions on interest rates and on the opening of new banks. In 1986, with the entry in the European Economic Community, Portugal witnessed a progressive relief in these regulation as part of the political commitment made to carry out an economic and financial integration that led to the formation of the Single Market. Alongside these changes, at the end of the decade with the goal of achieving a higher degree of liberalization of the financial markets a group of countries members of the Organization for Economic Co-operation and Development (OECD) worked together on achieving an agreement on the regulatory minimum own funds that should be held by banks. The culmination of this process led to the issuing of the Basel Capital Accord in 1988 under the jurisdiction of the Banks of International Settlements (BIS). In Portugal, the Capital Accord was only fully implemented five year later in 1993. With this accord in place, the Portuguese banks' own funds became subject to a "minimum limit corresponding to 8 per cent of their assets, after applying weighting factors intended to reflect the risk of each exposure" along with other restrictions concerning the composition of own funds.

The study mentioned above investigates the main factors that determine Portuguese banks' capital buffers, through an unbalanced panel of yearly data concerning 17 Portuguese banking groups from 1994 to 2004. Boucinha and Ribeiro (2007) were able to conclude that banks adjust their buffers in order to respond to changes in the risk they face (both internally, from their own management decisions and externally, resulting from changes in the macroeconomic environment), implying that when the risk is higher, the capital buffer is larger to deal with the higher probability of default associated to risker decisions. Yet, it was not

possible to identify the effects of the regulator's explicit and implicit intervention that cause banks to apply corrective measures of a prudential nature.

This paper contributes to the literature by shedding light on the Portuguese banking reality between 2008 and 2019 by trying to understand the determinants of the Portuguese banks capital and credit to the economy through the model developed by Shrieves & Dahl (1992).

3. Institutional Setting

3.1 Brief Historical Contextualisation of the Portuguese Banking System

At end of the 1980's, after the Portuguese revolution known as "25 de Abril" took place in 1974, the processes of privatization of the banks and industries stared to take place in Portugal in order to reduce the state's intervention in the economy and foster private investment in order to increase productivity and competitivity in Portuguese companies. During the 1990's the Portuguese state devoted its efforts to denationalizing some key industries which helped decrease its budget deficit (Silva, 2013). Since the end of the 20th century all the infrastructures financed by the Portuguese state (like for example the Expo 98', football stadium and highways) had a very low impact on economic growth (Silva, 2013) all these choices reflected a poor long-term vision on the investments, by the parties in power at the time, in the future e sustainability of the Portuguese economy. In addition to this, due to the low interest rates, credit was easy to access leading to the indebtedness of the Portuguese state, companies and families (specially with mortgages, that had huge weight on the total Portuguese credit). This reality combined with raising unemployment rates and all these conditions mentioned above made the Portuguese economy fragile and very dependent on the real estate market. So, when the collapse of the subprime market took place in the United States of America in 2007 and had the domino effect on other financial institutions around the world, it rapidly started to affect the, already fragile, Portuguese economy. Silva's (2013) findings concluded that the collapse of the financial institutions in the beginning of 2008 lead to difficulties in accessing credit that resulted in a decline in consumption and private investment. This had immediate consequences in all areas of the economy from a diminish in production to a raise of unemployment and severe social consequences.

By the end of 2008, together with most international economies, Portugal entered a recession period. Due to the assistance the financial sector received from the Portuguese state and due to the economic crisis, the fiscal deficit increased becoming one of the largest in the euro zone with 10.2% (Barradas et al., 2018). The consequences identified by Barradas et al., (2018) included increase of private indebtedness, however this increase of debt did not reflect a significant economic growth. Non-performing loans, especially in credit to consumption and some industries, rose considerably. Lastly, Barradas et al., (2018) was able to identify that indebt households and businesses became more vulnerable and subject to increases in interest rates and fluctuations in the business cycle. All things considered the confidence of foreign investors in the Portuguese economy decreased which represented a reduction in the

credit rating of Portuguese's companies and State. With that said, the euro area showed lack of instruments and mechanism to aid countries that faced liquidity crisis, that later became a solvency crisis.

From 2011 to 2014, the Portuguese government was subjected to financial assistance from the European Union (EU), the International Monetary Fund (IMF) and the European Central Bank (ECB) with a total funding of 78 billion euros. As a counterpart, the Portuguese government implemented structural reforms with the goal to "increase potential output growth, the deleveraging of the financial system and a trajectory of fiscal consolidation" (Barradas et al., 2018). After 3 years of economic recession, Portugal was able to regain confidence in the debt market, however the social consequences of the crisis were still present in the Portuguese society and by the end of 2016 the GDP, employment rate and Gross Fixed Capital Investment were all still below pre-crisis levels (Barradas et al., 2018).

This displayed the fragilities of the Portuguese economy and it's clear that a true economic recovery is only possible after resolving problems that exist in terms the structural supply weaknesses in the Portuguese economy and the debt legacy that prevents all economic sectors and the economy as a whole to thrive (Barradas et al., 2018).

It's true that between 2013-2019 the Portuguese economy had managed to reduce its deficit in the current account, a lot due to the expansion of the tourism sector. Despite the efforts made to stimulate de economy the Portuguese public debt (117.2% of the GDP) was still above the EU average that is situated in 85.9% in 2019 (Lagoa, 2021, pp. 54–55). As mention before the Portuguese economy has been facing structural problems in the last decades limiting the ability to react to economic shocks. Lagoa (2021, pp. 54–55) adds that Portuguese companies have been reducing their own funds and the savings levels of the Portuguese families are alarmingly low.

The subprime crisis and, especially, the sovereign debt crisis deeply affected the Portuguese banking sector. In 2019, non-performing loans were 6.1% well above the EU average of 3.1%, forcing banks to restructure their operations and even leading to the resolution of two major banks (BES and BANIF) and to the need for a significant injection of public money in Caixa Geral de Depósitos (CGD). In addition to non-performing loans, banks became less profitable due to new the regulations implemented in 2010 (Basel Acord III) that demanded higher capital ratio requirements (despite the fact that operation costs were reduced) making the system fragile and instable. A vulnerable banking system like the Portuguese is even more sensitive when faced with unexpected crisis, for instance the most recent COVID-19 pandemic in 2020, that provoked an abrupt drop in demand, economic growth and exports, reinforcing the structural problems mentioned above and forcing the

government to act rapidly and leading to a raise in public debt and deficit (Lagoa, 2021, pp. 54–55).

3.2 Subprime Crisis and its Consequences in terms of Banking Regulation

The 2007 financial crisis became an economic crisis and had a huge impact on the world economy, leading to the 1st global level recession since World War II and economic Depression. This crisis had its origin in one of the most high-risk markets in the world, the American subprime mortgage market. One of the main characteristics of these types of loans is the huge risk of non-compliance. A climate of instability and uncertainty hovered over the interbank market, which lead to a distrust between financial institutions resulting in liquidity shortage and in extreme cases bankruptcy (Gonçalves, 2015). Looking at the bigger picture, we can say that this crisis had its origin in the excessive indebtedness. In retrospect, we can identify that one of the main causes for this excessive debt was the lack of a competent and adequate financial supervision. This resulted in the fact that the financial institutions carried out high-risk transactions without the proper capital levels do manage the risk levels assumed. The period prior to the begin of the crisis was marked by great economic conditions, low interest rates and liquidity, culminating in an increase in consumption and investment (Gonçalves, 2015). This conditions also demonstrate that there were major failures in terms of regulation and supervision. Lagoa et al. (2015) identifies the incorrect rating by rating agencies, the competitive pressure and a weak regulatory framework (especially capital regulation) that focused in the assumption that banks could regulate themselves, as drivers for the subprime crisis. Apart from the regulatory factors, the banks disarticulate vision of risk, weak internal communication and risk control and lacked overall strategy also contribute for the risk management deficiencies, as well as the inappropriate assessment of risk and low transparency that also play a role in risk management failures. The crisis led to a weakening of the state finances of the euro zone, with deep impact on several countries across the European Union, like for example Portugal.

A major consequence of the subprime crisis for the banking sector as to do with the reinforcement supervision and regulation, especially form the International Monetary Fund (IMF) and the Financial Stability Board (FSB). Gonçalves (2015), points out the key instruments used by the IMF to help countries deal with the consequences of the crisis such as technical assistance, bilateral/multilateral supervision do ensure financial stability and financial aid to assisted country that faced serious balance of payments problems - as was the case of Portugal in 2011.

At a European level, this crisis exposed the weakness of the financial supervision authorities of the European Union (EU). With that said and with an attempt to correct, improve and prevent further damage the European System of Financial Supervision (ESFS) was created in 2010. The ESFS is composed by three European Supervisory Authorities (ESAs) – the European Banking Authority (EBA), the European Securities and Market Authority (ESMA) and the European Insurance and Occupational Pensions Authority (EIOPA) – that ensure the regulations are correctly applied and the European Systemic Risk Board (ESRB) that supervises systemic risk (Rakić & Dessimirova, 2018). However, national authorities are still responsible por the daily supervision of the financial sector – in the euro area they only supervise the smallest banks (Gonçalves, 2015).

The Basel Accords were also revised as a consequence of the 2007-09 world crisis. Figure 3.1 shows us a quick overview of the evolution of the Basel accords throughout the last years.

The 2007-09 crisis, that originated in the American subprime market and that later affected the entire world economy, exposed the vulnerabilities and fragilities of the Basel II Acord that was developed just a few years earlier. This made clear that there was a need for a new model of regulation and supervision since the former model had a less macroprudential view and considered the stability of each financial institution alone. Taking into consideration that this model failed to prevent the 2007-09 crisis, there was a need to develop a more macroprudential model that would take into account the effects every financial institution has in the entire system. Crisis like this emphasized the rapid transmission of shock between financial institutions and the economy as a whole (Figueiredo, 2017).

The Basel III was developed in 2010, started being implemented in 2013 and was completely in practice by 2019. It was intended to tackle the weakness of Basel II such as pro-cyclical capital requirements and the underestimation of the liquidity risk. This accord focused on capital, liquidity and credit concession requirements.

1988 - Basel I

•Agreement for the application of minimum capital funds in accordance to risk levels
- Main focus almost exclusively in credit risk
- Establishment of 2 tiers of regulatory capital

2006 - Basel II

•Revision of the estimation methods for risk exposure:
- Incentivize financial institutions for risk management
- Focus aimed at market risk, credit risk and operational risk

2010 - Basel III

•Focus in the quality and quantity of Capital retained by the financial institutions:
- More rigorous definition of regulatory own funds
- Establishment of own funda reserveal risk
- Leverage Ratio

2017 - Basel III Reforms

•Revision of the estimation methods for risk exposure:
- Reduction of the variability of own funds
- Increase the level of granularity in the production of results

FIGURE 3. 1 - EVOLUTION OF BASEL ACCORDS (SOURCE: BANCO DE PORTUGAL)

Basel III had the objective to increase capital and its quality due to the aftermath of the financial crisis. The minimum regulatory capital requirements were modified (Table 3.1), for example the TIER 1 Capital ratio whet from 4% to 6% and is now formed by the Common Equity Tier (CET) 1 and the Additional Tier 1 (Figueiredo, 2017). If the bank falls below these ratios, it is considered under-capitalized and is subject to an intervention by the regulator. These changes in capital ratios had the goal of capturing of the banks' risk level.

TABLE 3. 1 - BASEL III CAPITAL RATIOS

$$\frac{\boldsymbol{CET\ 1\ Capital}}{\boldsymbol{Risk - Weighted\ Assets}} \geq \mathbf{4.5\%}$$

$$\frac{\boldsymbol{TIER\ 1\ Capital\ (CET\ 1 + Additional\ Tier\ 1)}}{\boldsymbol{Risk - Weighted\ Assets}} \geq \mathbf{6\%}$$

$$\frac{\boldsymbol{Total\ Capital\ (TIER\ 1 + TIER2)}}{\boldsymbol{Risk - Weighted\ Assets}} \geq \mathbf{8\%}$$

$$\frac{\boldsymbol{CET\ 1\ Capital}}{\boldsymbol{Consolidated\ Assets}} \geq \mathbf{4.5\%}$$

The Basel III Accord also introduced the Capital Conservation Buffer (CCoB). This capital buffer is intended to force the banks to preserve capital in stability periods to face possible future crisis. The CCoB is a capital buffer of 2.5% of a bank's total exposures that needs to be met with an additional amount of Common Equity Tier 1 capital. When this buffer isn't met, automatic safeguards apply to limit the amount of dividend and bonus payments the bank is allowed to make (ESRB, 2019). The changes imposed by Basel III could have a reflection in the banks' capital buffer, this is something that will be analyzed in the Results section of this thesis.

4. Empirical Model

4.1. A Simultaneous Equations Model with Partial Adjustment for Capital and Risk

Through the theories presented in section 2 we can conclude that capital and risk decisions are determined simultaneously. To factor this, we base our analysis on the simultaneous equations model developed by Shrieves and Dahl (1992).

The observed changes in capital and risk are not only product of the discretionary behaviour of the banks, as well as the result of exogenous shocks. In terms of capital, these exogenous shocks are expected to be the result of unanticipated changes in earnings. On the other hand, in respect to risk, these exogenous shocks are normally the result of unexpected economic developments like for instance changing asset or loan quality or a changing value of the loan collateral.

Given the above Shrieves and Dahl's (1992) model has the two equations present that reflect the observed changes in the banks' capital and risk levels. Each equation includes two components a discretionary adjustment and a change caused by factors exogenous to the bank:

$$\Delta CAP_{j,t} = \Delta^{\mathrm{d}} CAP_{j,t} + E_{j,t} \qquad (1)$$

$$\Delta RISK_{j,t} = \Delta^{d} RISK_{j,t} + S_{j,t} \qquad (2)$$

where $\Delta CAP_{j,t}$ and $\Delta RISK_{j,t}$ are the total observed changes in capital and risk levels, for bank j in period t. $\Delta^{d} CAP_{j,t}$ and $\Delta^{d} RISK_{j,t}$ are the discretionary changes in capital and risk that are endogenously determined. The buffer theory presumes that banks face adjustment costs, this may enable them from instantaneous discretionary adjustment, so we model the discretionary part of the observed changes using the partial adjustment framework so it reflects the fact that banks may not be able to adjust their desired capital ratio and risk levels instantaneously. This framework says that since exogenous shocks can cause the bank to move away from their target level of capital, banks will make adjustments to capital and risk in order to reach the desired target. Due to the fact that these adjustments may be costly, banks only partially adjust towards the target level. The partial adjustment framework assumes that the discretionary changes in capital and risk is proportional to the difference between the target levels and the levels existing in period $t-1$ translating in

$$\Delta^d CAP_{j,t} = \alpha\left(CAP^*_{j,t} - CAP_{j,t-1}\right) \quad (3)$$

$$\Delta^d RISK_{j,t} = \beta\left(RISK^*_{j,t} - RISK_{j,t-1}\right) \quad (4)$$

where $CAP^*_{j,t}$ and $RISK^*_{j,t}$ are the target capital and risk levels, $CAP_{j,t-1}$ and $RISK_{j,t-1}$ the actual levels of capital in the previous period and α and β are proportionality factors.

After plugging in equations (3) and (4) into equations (1) and (2) respectively, we can rewrite the observed changes in capital and risk as

$$\Delta\mathrm{CAP}_{j,t} = \alpha\left(\mathrm{CAP}^*_{j,t} - \mathrm{CAP}_{j,t-1}\right) + E_{j,t} \quad (5)$$

$$\Delta\mathrm{RISK}_{j,t} = \beta\left(\mathrm{RISK}^*_{j,t} - RISK_{j,t-1}\right) + S_{j,t} \quad (6)$$

we conclude that the observed changes in capital and risk in period t are the function of the target levels and the lagged levels of capital and risk, and exogenous shocks.

4.2. Definitions of Capital and Risk

The most common measures for capital present in the literature are the ratio of capital to total assets (RCTA) and the ratio of capital to risk-weighted assets (RCWA). Shrieves & Dahl (1992) and Heid (2004) used the first definition. Aggarwal & Jacques (2001) and Rime (2001) use both measures in separate specifications. The second measure become more used after the introduction of risk-based capital regulation for that reason, in this paper we will be using RCWA as the definition of capital.

Risk is more difficult to measure and define and there are several alternatives in the literature. Although there isn't a consensus on the best option to define the bank's risk, for this paper, we choose to use the ratio of risk-weighted assets to total assets (RWATA) as a measure of risk. The RWATA was proposed initially by Shrieves and Dahl (1992) and later used by Rime (2001) and Heid (2004) in their studies. The RWATA reflects the bank's decisions on the risk-taking with appropriate timeliness. The motivation for the choice of risk

measurement is that the allocation of bank assets among risk categories is the primary factor of a bank's risk.

4.3. Variables Affecting Changes in Banks' Target Capital and Risk Levels

4.3.1. Size

The natural log of total assets (lSIZE) is included in the capital and risk equations to capture size effects. Size could possibility influence the target risk and capital levels of the bank, due to its connection to risk diversification and investment opportunities. The size of the bank may also be an indicator of the bank's access to capital.

4.3.2. Current Profits

Current profits are expected to have a positive effect on a bank's capital ratio if the financial institutions prefer to increase capital through retained earnings rather than through equity issues. The bank's return of assets (ROA) is therefore included in the capital equation as a measure of profits with an expected positive effect on capital.

4.3.3 Current Loan Losses

The ratio of risk-weighted assets (RWA) to total assets is affected by current loan losses since it reduces the nominal amount of the RWA. These loan losses (LLOSS) are included in the risk equations and are expected to have a negative effect on risk.

4.3.4. Regulatory Pressure

As we saw in Section 2 of the paper, the buffer theory forecasts that a bank reaching the regularity minimum capital ratio has the tendency to boost capital and minimize risk to avoid the violation of capital requirements and the subsequential regulatory costs that represents.

On the other hand, in a more extreme strategy, a poorly capitalized bank tends to increase risk with the hopes that it could lead to higher returns leading to an increase in their capital.

If we analyse past literature, we are able to identify two different ways of measuring the regulatory pressure. The first one is the probabilistic approach developed by Ediz et al. (1998) and used in 2001 by Rime on his paper concerning capital requirements and bank behaviour in Switzerland. This approach reflects the impact of capital ratio's volatility on the probability of no complying with the legal requirements imposed by regulators. Heid (2004) further explains that this approach lays under the assumption that the bank's capital and risk decisions are limited by the regulatory pressure as the banks moves closer to the legal capital requirement. The definition of closeness depends on the absolute percentage difference between the current capital ratio and the minimum capital requirement and on the variability of the capital ratio. The second approach developed by Aggarwal and Jacques (2001) and also used by Rime (2001) that measure the regulatory pressure is the prompt corrective action (PCA) classification that separated adequately capitalized banks and undercapitalized banks. The rationale behind theses approach is that the quality of regulatory pressure changes once banks fall below certain legal capital regulatory requirement.

After considering these two different methods to define the regulatory pressure, we conclude that the PCA classification is the best option to measure the regulatory pressure.

4.3.5. Simultaneous Changes in Risk and Capital

The models and theory discussed above in Section 2 assume that banks define simultaneously the levels of capital and risk. This means that the banks' capital and risk decisions are interdependent, which forces us to include both variables on the right-hand side of the two equations of the model. A positive relationship between changes in RWATA and RCTA is in line with the expectation that banks are not obliged to adjust risk and capital in the same direction to maintain their default probability at an adequate level.

4.3.6. Regulatory Shocks and Macroeconomic Shocks

Macroeconomic shocks may affect the demand for and structure of loans as well as the supply of deposits can affect the banks' capital ratios and risk. To take this into account the macroeconomic and the regulatory context that might systematically affect and impact the

observed risk and capital in any given year we add dummy variables to the specification for each year of the reference period.

4.4. Specification

Based on the analysis conducted on the previous section, the empirical model defined by the equations. (5) and (6) is specified as follows:

$$\Delta CAP_{j,t} = a_0 + a_1 \cdot REG_{j,t-1} + a_2 \cdot ROA_{j,t} + a_3 \cdot lSIZE_{j,t} + a_4 \cdot \Delta RISK_{j,t} + a_5 \cdot CAP_{j,t-1} + \varepsilon_{j,t} \quad (7)$$

$$\Delta RISK_{j,t} = a_0 + a_1 \cdot REG_{j,t-1} + a_2 \cdot LLOSS_{j,t} + a_3 \cdot lSIZE_{j,t} + a_4 \cdot \Delta CAP_{j,t} + a_5 \cdot RISK_{j,t-1} + v_{j,t} \quad (8)$$

To estimate the model, we will use the method of instrumental variables (IVs). This method is a general approach to the estimation of causal relations using observational data.

5. Data Description, Empirical Methodology and Results

5.1. Data and Empirical Methodology

The data used in this paper was extracted from the Historical Series of the Portuguese Banking Sector database that is collected and developed by an internal working group at Banco de Portugal (Banco De Portugal Microdata Research Laboratory (BPLIM), 2020). The sample used in this paper consists in 375 observations of Portuguese banks over the period 2008 to 2019. The reasoning for the selection of this time period is to be able to include the 2007-09 financial crisis and to observe the bank's behaviour in a post-crisis economy.

The cross-sectional data is pooled over the twelve years of our reference period stated above as was made by Shrieves and Dahl (1992), Jacques and Nigro (1997), Aggarwal and Jacques (2001) and Rime (2001). To take into consideration the time dimension of the sample we included dummy variables for each year (with the exception of the first year) of the reference period. The inclusion of the dummy variables in the regressions is to capture time-specific fixed effects that are not controlled by other explanatory variables.

We decided to only include in the sample banks with total assets higher than 600 million euros, this way eliminating banks we consider too small to take into account. Apart from that every estimation has an additional condition of variables $\Delta CAP_{j,t}$ smaller than 20 to eliminate outliers leaving us with the total of 375 observations along the 12 years.

Table 5.1 presents a brief description of the all the variables included in the model. As mention before in section 4, to capture the size effects on both the capital and risk equations, we include the natural log of total assets ($lSIZE_{j,t}$). To take into account the effect of current profits in the capital equation we divide the net profits/loss with total assets ($ROA_{j,t}$) this variable is expected to have a positive effect on capital, on the other hand we expect a negative effect of the bank´s current loan losses on the risk equation so we include the variable $LLOSS_{j,t}$ that is a result of the ratio between provisions & impairments to total assets. Furthermore, after opting the PCA classification approach when measuring the regulatory pressure, we defined a lagged dummy variable $REG_{j,t}$ that can assume two possible values: 1 if the bank's total capital ratio is between 8% and 10% and 0 otherwise.

The variables $RISK_{j,t-1}$ and $CAP_{j,t-1}$ are meant to capture the lag of the corresponding variables. Lastly since we are developing a simultaneous model with partial adjustments, the variables $\Delta CAP_{j,t}$ and $\Delta RISK_{j,t}$ represent the observed changes in capital and risk in period t.

These variables, as we can see in equations (5) and (6), are a result of the function between the target levels and the lagged capital and risk levels, and exogenous factors. As previously referred, we opted for the ratio of total capital to total risk-weighted assets as a measure for capital and for risk the chosen measurement was the ratio of risk-weighted assets to total assets due to the fact that the allocation of bank assets among risk categories is the primary factor of a bank's risk.

Table 5.2 displays a summary of the variables used in the simultaneous equations model. In terms of size, we can state that the average size of the banks used in the estimation is 14 053 million euros. The average return on assets is 0.24% and the mean of loan losses resulting from the ratio between provisions & impairments to total assets is 0.98%. The ratio of total capital to total asset's mean among the observations used in this paper is 13.79%. The variable REG has a mean of 0.08, this translates into 8% of the observations are equal to 1, meaning that they have a capital ratio in between 8% and 10%. Due to some restrictions imposed by Banco de Portugal, we aren't able to display the minimum and maximum values of each variable.

TABLE 5. 1 - DESCRIPTION OF VARIABLES

Variable	Description
ΔCAP	Change in the ratio of total capital to total risk-weighted assets (regulatory ratio)
CAP	Ratio of total capital to total risk-weighted assets
$\Delta RISK$	Change in the ratio of risk-weighted assets to total assets
$RISK$	Ratio of risk-weighted assets to total assets
$lSIZE$	Log of total assets
REG	Dummy variable equal to 1 when the bank's total capital ratio is between 8% and 10% and 0 otherwise
ROA	Return on assets
$LLOSS$	Ratio of provisions and impairments to total assets

TABLE 5. 2 - VARIABLE'S SUMMARY

	Obs	Mean	Std. Dev.
$SIZE$ (Millions of euros)	375	14053.63	25671.88
ROA	375	.0024911	.0352412
CAP (%)	243	13.79865	12.33672
$RISK$	243	.6353271	.1780583
$LLOSS$	375	.0098127	.0320575
REG	375	.08	.2716556
$lSIZE$	375	8.208581	1.568548

Table 5.3 shows us the correlations between all variables present in both equations. We can identify that the correlation between the lagged levels of Capital and Risk and the first differences of Capital and Risk, respectively, are negative. This conclusion is partially in line with the discoveries of Shrieves and Dahl (1992), where there was also found a negative correlation between Capital and Risk. However in terms of the correlation between the first differences of CAP and RISK Shrieves and Dahl (1992) found a positive correlation and in this thesis we observe a negative correlation between these two variables. Shrieves's explanation for the negative correlation between levels of Capital and Risk is based on the cross-section variation in risk preferences meaning that, banks with higher risk aversion are expected to choose high capital ratios and low risk and on the other hand banks that tend to have a lower aversion to risk would choose lower capital ratios and high risk. It is important to highlight, that the correlation between $REG_{j,t-1}$ and the variation of capital is positive (0.0400), on the other hand, we can observe a negative correlation between $REG_{j,t-1}$ and the variation of the risk levels (-0.0159).

TABLE 5. 3 - CORRELATIONS AMONG VARIABLES

	$\Delta CAP_{j,t}$	$CAP_{j,t-1}$	$REG_{j,t-1}$	$ROA_{j,t}$	$lSIZE_{j,t}$	$\Delta RISK_{j,t}$	$RISK_{j,t-1}$	$LLOSS_{j,t}$
$\Delta CAP_{j,t}$	1.0000							
$CAP_{j,t-}$	-0.5752	1.0000						
$REG_{j,t-}$	0.0400	-0.2363	1.0000					
$ROA_{j,t}$	-0.0369	0.3614	-0.2229	1.0000				
$lSIZE_{j,t}$	-0.0494	-0.2934	0.1041	-0.3599	1.0000			
$\Delta RISK_{j}$	-0.2336	0.1625	-0.0159	0.0736	-0.1126	1.0000		
$RISK_{j,t-}$	0.0304	-0.1874	0.0423	0.0226	-0.0037	-0.2456	1.0000	
$LLOSS_{j,}$	-0.0724	-0.1252	0.0527	-0.3712	0.0641	-0.0176	0.3527	1.0000

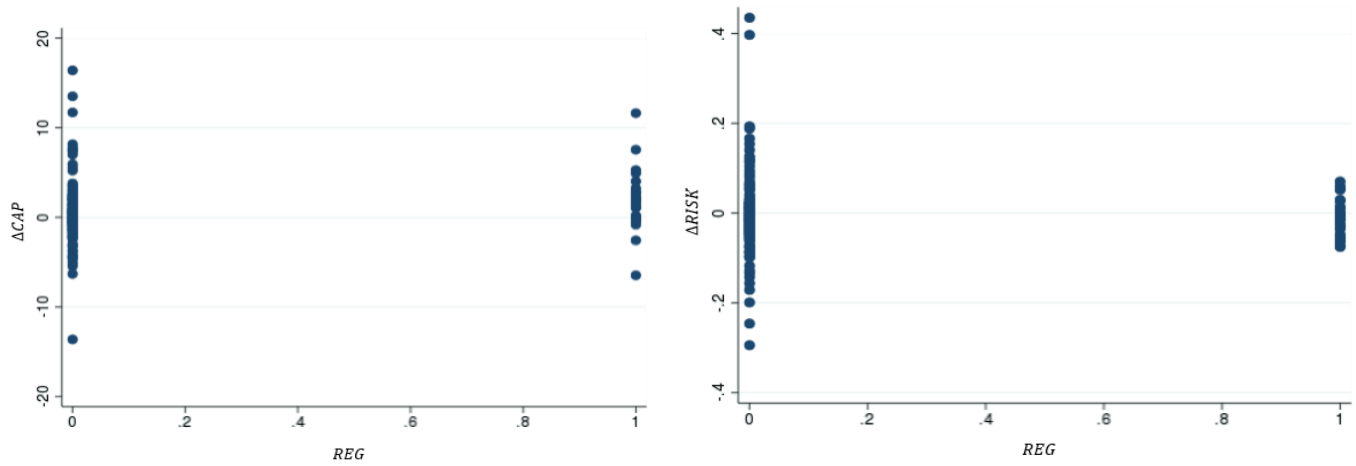

FIGURE 5. 1 – SCATTER GRAPH OF FIRST DIFFERENCES OF CAPITAL AND REGULATORY PRESSURE & FIRST DIFFERENCES OF RISK AND REGULATORY PRESSURE

Figure 5.1 show us the relationship between the first differences of capital/risk and regulatory pressure. It is possible to observe that banks with $REG = 1$ tend to have a greater deviation when related to changes in capital (positive changes are more than the negative changes when compared with the cases for reg=0), however there is a great dispersion of the observations. Then compared to the changes in risk, the difference in the dispersion of the observations between banks with $REG = 1$ and $REG = 0$ is not that clear, probably due to the existing tendency for $\Delta RISK$ to be lower than zero for most banks.

5.2. Results

5.2.1 Ordinary Least-Square Estimation

We begin by estimating our model as separate equations. To do so, we applied an Ordinary Least Square (OLS) regression with the robust option to each equation. However, this estimator has one important assumption referred to as exogeneity. The OLS estimator requires regressors to be exogenous and if we look at our model equations (7) and (8), we can identify that due to the fact that both capital and risk are determined simultaneously the variables are endogenous. This indicated there is correlation between the variables and the error term meaning the regression is biased and inconsistent. We present these results as a first step in our empirical estimation and later on, the endogeneity of the variable will be taken into account. Table 5.4 and 5.5 shows us the results for both Capital and Risk OLS regressions, respectively.

The first important point to referrer after analyzing the OLS regressions is that not all variables are statistically significant to explain the variations in the capital ratios and risk levels.

It's interesting to point out the regulatory pressure (REG) only positively and significantly affects the capital ratio and is not significantly relevant to explain the banks' level of risk, this finding is consistent with the previous finding by Rime (2001). This may indicate that that banks that are closer to the meeting the minimum capital requirements tend to increase capital in order to try to comply with the legal requirements, however to anticipate any problem that might occur and to project a positive image to the regulatory authorities and stakeholders, banks that are above the minimum requirement also increase their buffers. In terms of the impact on risk-taking decisions, the regulatory pressure is statistically insignificant so we can conclude that risk levels are not affected by capital requirements. For both the capital and risk equations we can claim that there is a negative and significant relationship between the changes in capital and risk levels, respectively.

TABLE 5. 4 - OLS ESTIMATION OF CAPITAL EQUATION

ΔCAP	Coef.	Std. Err.	P>|t|
CAP_{t-1}	-.0479954	.0719147	0.505
REG_{t-1}	1.367448 **	.6573453	0.039
ROA_t	7.773403	24.58162	0.752
$lSIZE_t$	-.2265947 *	.1268374	0.076
$\Delta RISK_t$	-13.33256 ***	4.800665	0.006
$dum2009$	-.3583717	.8717091	0.681
$dum2010$	-1.905121**	.8145463	0.020
$dum2011$	-1.777162 **	.8750578	0.044
$dum2012$	-.2468165	.9656763	0.799
$dum2013$		(omitted)	
$dum2014$	-1.514021	.8800337	0.087
$dum2015$	-1.390928	.8727343	0.113
$dum2016$	-1.347578	.8823631	0.128
$dum2017$	.9093281	1.15195	0.431
$dum2018$	-1.740349	1.00696	0.086
$dum2019$	1.916079	1.199677	0.112
$\_cons$	3.714196	1.958933	0.059

Note: *, **, *** Significance at the 10, 5 and 1% levels of significance, respectively

TABLE 5. 5 - OLS ESTIMATION OF RISK EQUATION

$\Delta RISK$	Coef.	Std. Err.	P>|t|
$RISK_{t-1}$	-.1085784 ***	.0319494	0.001
REG_{t-1}	.0116474	.0117042	0.321
$LLOSS_t$	.513307	.4850387	0.291
$lSIZE_t$	-.0061049 **	.0027939	0.030
ΔCAP_t	-.0072658 ***	.0015031	0.000
$dum2009$	-.0221623	.0244121	0.365
$dum2010$	-.0293544	.0197272	0.138
$dum2011$	-.010805	.0202077	0.593
$dum2012$	-.0199839	.0193241	0.302
$dum2013$	-.0246885	.019766	0.213
$dum2014$	.0170973	.0281372	0.544
$dum2015$		(omitted)	
$dum2016$	-.0391057 *	.0219986	0.077
$dum2017$	-.0209383	.0195596	0.286
$dum2018$	-.025594	.0186775	0.172
$dum2019$	.0058863	.0183166	0.748
$\_cons$	.1268632	.0399425	0.002

Note: *, **, *** Significance at the 10, 5 and 1% levels of significance, respectively

5.2.2. Arellano–Bond Linear Dynamic Panel-Data Estimation

To improve our model and obtain better results, we also estimated both equations with the Arellano–Bond linear dynamic panel-data estimation (table 5.6 and 5.7). This estimator is suited for datasets with many panels and few periods, and where the lagged dependent variable is an explanatory variable. In the risk equation, we estimated the model with $\Delta RISK$ as an endogenous variable and used the additional instrument $LLOSS$. On the other hand, in the capital equation the estimation is made with ΔCAP as the endogenous variable and ROA as the additional instrument variable. These instruments were used in the previous literature, the reason for this choice of instruments lay in the fact that in $LLOSS$ (ROA) is expected to have an effect in the level of risk (capital) however it doesn't have a correlation with the error term present in the capital (risk) equation.

To test our estimation, we performed an autocorrelation test and an overidentification test for each of the equations. In the capital equation, after testing for autocorrelation we were able to assume that there is no autocorrelation (second and third-order autocorrelation's $prob > z = 0.0940$ and $prob > z = 0.3854$ meaning we do not reject the null hypothesis). However, when testing if the overidentifying restrictions were valid, the $prob > chi2 = 0.0091$ meaning we rejected the null hypothesis concluding the overidentifying restrictions weren't valid. We

tried to eliminate his condition, by adding more instrumental variables, predetermined variables and exogenous variables but were not able. The presence of heteroskedasticity causes the test to reject the null hypothesis.

In the risk equations, after applying the Sargan test we can reject the null hypothesis ($prob > chi2 = 0.5486$) and state that the overidentifying restrictions are valid. When testing for autocorrelation, we analyse the second and the third-order correlation (with a p-value of 0.2847 and 0.1879 respectively), meaning we do not reject the null hypothesis state that there is no evidence of model is misspecification. When analysing the first-order correlation, we would accept the null hypothesis however it is not an indication of misspecification of the model.

From the results of this estimation, we can highlight that the banks' size ($lSIZE$) has a negative impact on both risk levels and the capital ratio. The negative effect on capital is excepted, which means that probably due to access to alternative funds. Larger banks' target capital buffer is smaller than smaller banks resulting in the fact that they don't have the need to increase capital as much as the smaller banks have. Nevertheless, the negative impact the banks' size has on risk is in line with Heid's (2004) findings but contrasts with Rime (2001) that found positive effect on risk, meaning bigger banks have a lower target risk levels than smaller banks. Another interesting outcome is that the regulatory pressure (REG) has a positive and significant impact only on the capital levels. This is an expected result due to the fact that banks with smaller capital regulatory buffers are expected to raise their capital levels.

Both ROA and $LLOSS$ have significant and positive effects on their respective equations. The first one is expected, however the effect LLOSS was expected to have on the risk levels was negative. This may be due to the fact that banks with higher level of risk appetite are more willing to take risks.

When we analyse the relationship between the observed changes in the level of capital and the level of capital in the previous period, we can observe that the value is -0.14. Since in the Arellano Bond estimation, we are using capital as de dependent variable (as we can see in equation (9)), and not the change of capital, the coefficient $\alpha 5$ in equation (7) is $-0.14 - 1 = -1.14$, with a p-value of 0.000. The coefficient is clearly different from zero, showing also a very quick adjustment of capital. On the other hand, the effect that the risk level from the previous period has on the observed changes of risk, $\alpha 5$ in equation (8), has a value of $0.88 - 1 = -0.12$, with a p-value of 0.34. so, we can conclude the exact opposite indicating that change in risk doesn't adjust to $RISK_{t-1}$.

$$CAP = 0 + \alpha 2' \cdot CAP_{j,t-1} + \alpha 3 \cdot ROA_{j,t} + \alpha 4 \cdot lSIZE_{j,t} + \alpha 5 \cdot REG_{j,t-1} + \alpha 6 \cdot \Delta RISK_{j,t} \quad (9)$$

$$\Delta CAP = \alpha 0 + \alpha 2 \cdot CAP_{j,t-1} + \alpha 3 \cdot ROA_{j,t} + \alpha 4 \cdot lSIZE_{j,t} + \alpha 5 \cdot REG_{j,t-1} + \alpha 6 \cdot \Delta RISK_{j,t} \quad (10)$$

$$\alpha 2' = \alpha 2 + 1 \quad (11)$$

$$RISK = \alpha 0 + \alpha 2' \cdot RISK_{j,t-1} + \alpha 3 \cdot LLOSS_{j,t} + \alpha 4 \cdot lSIZE_{j,t} + \alpha 5 \cdot REG_{j,t-1} + \alpha 6 \cdot \Delta CAP_{j,t} \quad (12)$$

$$\Delta RISK = \alpha 0 + \alpha 2 \cdot RISK_{j,t-1} + \alpha 3 \cdot LLOSS_{j,t} + \alpha 4 \cdot lSIZE_{j,t} + \alpha 5 \cdot REG_{j,t-1} + \alpha 6 \cdot \Delta CAP_{j,t} \quad (13)$$

$$\alpha 2' = \alpha 2 + 1 \quad (14)$$

It is also interesting to denote that the time dummies for 2017, 2018 and 2019 have a positive and significant effect on the level of capital. This could possibly mean that, during this 3-year time period, there was a transverse systematic effect across all banks. This could be caused by a general increase of capital ratios, in line with the conditions imposed by Basel III and taking advantage of the climate of economic growth to do so.

TABLE 5. 6 - ARELLANO–BOND LINEAR DYNAMIC PANEL-DATA ESTIMATION OF CAPITAL EQUATION

CAP	Coef.	Std. Err.	P>|z|
CAP_{t-1}	-.0140948	.0288701	0.625
$\Delta RISK_t$	-10.16118	8.562112	0.235
REG_{t-1}	.6941567 **	.346869	0.045
ROA_t	69.44706 **	33.79168	0.040
$lSIZE_t$	-9.433647 ***	1.800974	0.000
$dum2009$	-.3101099	1.098059	0.778
$dum2010$	.0731227	1.035679	0.944
$dum2011$	-.2615928	.980945	0.790
$dum2012$	.3358471	1.274824	0.792
$dum2013$	1.660689	1.09836	0.131
$dum2014$	.3685874	.4518491	0.415
$dum2016$	.3085609	.523917	0.556
$dum2017$	3.0124 ***	.715061	0.000
$dum2018$	3.131975 ***	.8424074	0.000
$dum2019$	5.560294 ***	1.237843	0.000
$\_cons$	97.41301	16.49495	0.000

Note: *, **, *** Significance at the 10, 5 and 1% levels of significance, respectively
Instruments for differenced equation
GMM-type: L(2/4).CAP L(2/3).drisk
Standard: D.lreg D.ROA D.lsize D.dum2010 D.dum2011 D.dum2012 D.dum2013 D.dum2014 D.dum2015 D.dum2016 D.dum2017 D.dum2018 D.dum2019 LLOSS
Instruments for level equation
Standard: _cons

TABLE 5. 7 - ARELLANO–BOND LINEAR DYNAMIC PANEL-DATA ESTIMATION OF RISK EQUATION

$RISK$	Coef.	Std.Err.	P>|z|
$RISK_{t-1}$	.881598 ***	.1251405	0.000
ΔCAP_t	-.0006255	.0005836	0.284
REG_{t-1}	.0136023	.0115014	0.237
$LLOSS_t$	1.729848 ***	.6388674	0.007
$lSIZE_t$	-.1263662 **	.0555042	0.023
$dum2009$	-.0300153	.0289039	0.299
$dum2010$	-.0119907	.0267552	0.654
$dum2011$	.0044272	.0214043	0.836
$dum2012$	-.0274285	.0258557	0.289
$dum2013$	-.032111	.019911	0.107
$dum2014$	.0194899	.0241201	0.419
$dum2016$	-.0230695	.0162828	0.157
$dum2017$	-.0093252	.0209312	0.656
$dum2018$	.0109744	.0224394	0.625
$dum2019$	.0282723	.0190707	0.138
$\_cons$	1.173579	.4954576	0.018

Note: *, **, *** Significance at the 10, 5 and 1% levels of significance, respectively
Instruments for differenced equation
GMM-type: L(2/4).RISK L(2/3).dcap
Standard: D.lreg D.LLOSS D.lsize D.dum2010 D.dum2011 D.dum2012 D.dum2013 D.dum2014 D.dum2015 D.dum2016 D.dum2017 D.dum2018 D.dum2019 ROA
Instruments for level equation
Standard: _cons

5.2.3. Three-Stage Least-Square Estimation

As referenced before, the OLS estimator did not take into account the endogenous variables present in the simultaneous equation model. For this reason, we could estimate equations (7) e (8) using the three-stage least-square (3SLS) or the two-stage least-square (2SLS) estimator that enables us to take into consideration the endogeneity properties of the simultaneous equation model and deliver consistent results. The 3SLS not only generates asymptotically more efficient results than 2SLS but uses the information that the disturbance terms in the two structural equations are contemporaneously correlated. This is an alternative do the estimator Arellano-Bond and is widely used in the literature (see (Aggarwal & Jacques, 2001; Bougatef & Mgadmi, 2016; Heid et al., 2004; Jacques & Nigro, 1997; Rime, 2001; Shrieves & Dahl, 1992).

The results of the 3SLS estimation are present in Table 5.8. It is important to stress out that, ROA is an instrument for capital, so it is only included in the capital equation. The same logic is applied in the LLOSS variable that is used as an instrument for the risk levels. We continue to observe that the bank's size has a negative significant impact on the risk levels. But it is important to mentation that the regulatory pressure that in the previous estimations

had a positive and significant effect on the capital levels, in this estimation it loses its significance.

The downside of this estimation in comparison to the Arellano-Bond linear dynamic panel-data estimation, that in this last one we were able to include more instruments and produce robust results (obtain robust standard deviations). For this reason, we tend to value more the output of the Arellano-Bond estimation.

TABLE 5. 8 - 3SLS ESTIMATION

ΔCAP				$\Delta RISK$		
	Coef.	**Std. Err.**	**P>|z|**	**Coef.**	**Std. Err.**	**P>|z|**
CAP_{t-1}	-.0787455	.0485022	0.104			
$lREG_{t-1}$	1.260212	.81268	0.121	.009605	.0212037	0.651
ROA_t	16.74662	20.08604	0.404			
$lSIZE_t$	-.0708487	.1816886	0.697	-.0059675 **	.0029049	0.040
$\Delta RISK_t$	21.58223	17.01939	0.205			
$RISK_{t-1}$				-.1064287***	.0325644	0.001
$LLOSS_t$				.5620379	.4575482	0.219
ΔCAP_t				-.0058861	.0110104	0.593
$dum2009$	-1.30383	1.244056	0.295	-.0265332	.0249348	0.287
$dum2010$	-3.262462	1.197412	0.006	-.0311176	.0414309	0.453
$dum2011$	-4.048903	1.19511	0.001	-.0122161	.045182	0.787
$dum2012$	-1.73602	1.191163	0.145	-.0241618	.028401	0.395
$dum2013$	-1.190477	1.232262	0.334	-.0291318	.0262079	0.266
$dum2014$	-4.828505	1.366412	0.000	.0160093	.0471484	0.734
$dum2015$	-3.773632	1.21927	0.002	-.0017082	.0408962	0.967
$dum2016$	-2.127475	1.284118	0.098	-.0416121	.0354398	0.240
$dum2017$	-.1694528	1.234519	0.891	-.0263044	.0204787	0.199
$dum2018$	-3.422146	1.147798	0.003	-.0265136	.043438	0.542
$dum2019$		(omitted)			(omitted)	
$\_cons$	4.759535	2.071844	0.022	.1262379	.0594656	0.034

Note: *, **, *** Significance at the 10, 5 and 1% levels of significance, respectively

6. Conclusions

In this study, we have examined the Portuguese banks' capital and risk behaviour during the period from 2008 to 2019. The reason for the selection of this particular time period is that it includes the 2007-09 financial crisis and to observe the bank's behaviour in a post-crisis economic climate. The subprime crisis and the sovereign debt crisis had a huge impact on the Portuguese banking sector, that has already been showing signs of structural problems since the previous century, leading to a raise in non-performance loans and to a liquidity problem that even translated in the bankruptcy of BES and BANIF and the need for a state intervention in CGD's capital. Portugal entered a recession period; the public deficit rose and the social consequences were terrible for the Portuguese people. The Portuguese government was subjected to international financial assistance of 78 billion euros. By analysing and identifying the main determinants of Portuguese banks' capital and credit to the economy we are able to comprehend the impact regulation has when defining internal capital buffers and how other factors, like size for example, add to the determination of the bank´s internal capital ratios and the amount of risk they are willing to take in their operations. To do so, we used a modified version of the model developed by Shrieves and Dahl (1992). This model takes into account that the changes in risk levels and capital ratios are interconnected and happen simultaneously. Moreover, as mentioned in section 2, when choosing the appropriate capital buffer and risk levels banks do face a decision between maximizing profits and satisfy their shareholders and having enough capital to avoid breaching any regulations and face sanction from the supervisory authorities. Another interesting factor that this model captures is the charter value theory that forecasts that the bank will maintain a level of capital above the capital buffer required by the regulators and supervising authorities. We estimated the model using both a 3SLS estimator and the Arellano-Bond linear dynamic panel-data estimator. As mentioned in the previous section, we value the Arellano-Bond estimation more due to the fact that it allowed us to include more instruments and generate more robust results. This estimator, unlike the simple OLS or the 3SLS estimator, took into account the endogeneity of the variables and used the lagged dependent variable as explanatory variable. The model includes dummy variables for each year to take into account the time dimensions of the sample.

Our results identify that the bank's size has a negative significant impact on both capital and risk levels. This result confirms previous literature where larger banks have an easier access to alternative funding and also demonstrate a lower target risk level. Moreover, the current profits and current loan losses have positive and significant impact on the equations of the model (capital and risk respectively). The first one is expected, because financial institutions prefer to increase capital through retained earnings rather than through equity

issues, however the positive effect of current loan losses in the risk levels is not expected nor in line with previous literature, this may be explained by the fact that banks with higher level of risk appetite are more willing to take risks.

We also found that the regulatory pressure has the desired effect on the bank's capital ratios, the REG variable has a positive and significant in the capital equation. Banks with smaller capital levels tend to raise their capital buffers to avoid non-compliance with the regulators, these findings are in line with the buffer theory and with previous literature. Also, in line with the literature it is important to empathize that the time dummy variables for 2017, 2018 and 2019 have a significant and positive impact on capital levels, this could be the direct effect the Basel III accord reforms and the positive economic climate that led to a general increase across the banks.

Finally, we observe that the capital changes adjust quickly to the capital levels of the previous period. However, when analysing the relationship between the changes in risk levels and the levels of risk in the previous period we have the opposite conclusion, meaning changes in risk do not adjust to risk levels of the previous period. The results of this paper show us that regulatory pressure is having the desired effect on bank's capital buffers, adding to the impact of profits, loan-losses, bank's size, and the levels of capital and risk in the previous years are key determinants for the bank's capital and credit to the economy. However, banks respond to regulatory pressure by increasing capital, and not by reducing risk, showing the impacts of capital regulation on reducing credit availability are not relevant. One of the limitations of this paper is the choice for the variables affecting the observed changes in capital and risk, and for that reason there is opportunity for future studies to include additional variables to model (for example the bank's liquidity). For future research it also possible to use different definitions for some variables, for example when measuring the regulatory pressure, it is possible to opt for the probabilistic approach instead of the PCA classification.

7. References

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