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**Essays on**  
**Understanding Assumption and**  
**Prevention of Undesirable**  
**Bank Risk**

**Ph.D. Dissertation**

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*“Not every mistake is a foolish one. “*

*Cicero, philosopher*

*“I suffered from the “Lehman Syndrome,” a kind of financial post-traumatic stress disorder. Sperling sometimes quipped that whenever anyone mentioned the word “systemic risk,” everyone’s IQ instantly dropped fifty points.”*

*Timothy F. Geithner, former Secretary of the Treasury United States (2014)*

*“(…) This is the central paradox of financial crises: What feels just, and fair is often the opposite of what is require for a just and fair outcome. Its why policy makers tend to make crises worse, and why the politics of crisis managements are always untenable.”*

*Timothy F. Geithner, former Secretary of the Treasury United States (2014)*

*“(…)Nothing brings home the fragility of the banking system or the potency of a financial crisis more vividly than writing about these issues from the eye of the storm. Watching the world’s central bankers and finance officials grappling with the current situation—trying one thing after another to restore confidence, throwing everything they can at the problem, coping daily with unexpected and startling shifts in market sentiment—reinforces the lesson that there is no magic bullet or simple formula for dealing with financial panics.”*

*Liaquat Ahamed, American author and economist (2009)*

**T**his work is dedicated to; Fini and Piliña - you always see me capable of doing more than I feel I can do- and specially to Laura- as this long doctoral adventure couldn't have been possible without you. I have always heard the importance of the thesis director. Now I certify that a thesis director is not only an academic guide but also a source of help, support, motivation, and resilience.

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## **Thesis abstract**

Banking crises are a global phenomenon that have frequently affected developing and transitioning economies (Caprio and Klingebiel, 1997). Risk is an inherent factor of the banking business, and an unfortunate development of bank risk cannot always be avoided. Across recent banking crises we can observe how flaws of the banking regulation has affected the banking risk intake. For this reason, the financial regulation has evolved trying to close the gaps in international banking supervision.

This thesis examines and aims to understand risk factors influencing the banks risk assumption under different conditions. Firstly, by looking at the banking risk factors in Latin America, a region which has experienced severed banking crises in the past. Secondly, and following the European sovereign debt crisis (Becker and Ivashina 2017; Ongena et al, 2019), we examine the risk factors that drive the sovereign exposure of small European Banks; Less Significant Institutions (LSI). Finally, we look at the upcoming banking regulation: The Fundamental Review of the Trading Book (FRTB), at this analysis we compare the risk measurement using the two different factors enabled by the regulation.

Through the different papers we confirm firstly how in the case of Latin America, traditional commercial banks with good capitalization and liquidity are less risky. Secondly, that LSIs with strong credit quality and low capitalization are more disposed to increase LSI investment in sovereign debt. Finally, how the loose guidance on the inputs needed to calculate the DRC (Default risk Capital), within FRTB, might affect the bank risk exposure calculation.



# 1

## **Introduction; Bank risk, crisis, and its implications for the real economy**

The objective of this thesis is to contribute to the banking literature by providing a better understanding of the bank risk-taking, analyzing bank risk factors, and studying upcoming banking risk regulation. For this purpose, in this dissertation, we analyze: two different banking realities) Latin American commercial banks across the period 1999 to 2013 and European small banks across the time span 2010 to 2017) and the upcoming regulatory changes reflected in the Default Risk Capital Requirement (DRC).

To introduce the field of research in this thesis we can start by simply describing the primary role for a bank. This main role of a bank consists in collecting deposits from savers and making loans to borrowers in need of funds. Through this process, banks also offer maturity transformation function, as they transfer funds from savers demanding short-term deposits to agents in deficit with long-term financing needs (Hicks, 1946). However, this maturity transformation favors banks' exposure to credit and interest rate risk. For these services banks charge fees that justify their risk intake and their intermediation. To be more profitable, banks might have incentives to assume additional risk by increasing the maturity mismatch (Brunnermeier and Oehmke, 2013) which would cause banks to increase their exposure to liquidity and funding risks.

Due to their key role in the economy, banks are highly regulated. The aim of the regulation is to ensure the resilience of the financial sector and financial stability<sup>1</sup>. With this purpose, banks are requested to hold funds (capital buffer) to withstand potential shocks and mitigate the disruptions in the financial intermediation process -as these disruptions could adversely impact the real economic activity (ECB, 2021).

### **1. Are banking crises inevitable?**

Banking crises<sup>2</sup> have occurred and will occur despite banks obligations to adhere their risk management to regulation. Although a Bank failure is unexpected, it tends to be enough information available in the economy, indicating that a banking system is vulnerable to a crisis (Hardy et al, 1998). This explains that banking crises cannot be seen as the inevitable result of human action or the structure of the banks' balance sheet and hostile macroeconomic conditions (Calomiris, 2010). As well Banking crises

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<sup>1</sup> ECB defines financial stability as a condition in which the financial system – which comprises financial intermediaries, markets, and market infrastructures – is capable of withstanding shocks and the unravelling of financial imbalances.

<sup>2</sup> Across the literature banking crises are defined either of panics or severe waves of bank failures accompanied by loses of capital that require the public intervention, bankruptcy or forced merged between institutions (Calomiris, 2010; Laeven and Valencia, 2008)

are a global phenomenon that have frequently affected developing and transitioning countries (Caprio and Klingebiel, 1997).

## **2. Risk is inherent to the banking business:**

As priorly mentioned, risk is inherent to the banking activity. From an etymology point of view, the word risk comes from the Italian word “risco” which means danger. However, as Stulz (2016) mentions, not all risks are bad for a bank. In fact, Certain levels of risk can be justified by certain investment opportunities in which taking risks might present an ex-ante reward on a standalone basis. As the author Stulz, (2014) indicates, banks optimal level of risk could be referred as that one in which the banks projects increase the bank’s value while considering the costs associated with the impact of the project on the bank’s total risk<sup>3</sup>.

Managing risk consists in the monitoring of potential adverse outcomes that could generate distress (Smith and Stulz 1985). Nevertheless, when a company is in distress, it is not capable of successfully implementing a strategy. The lack of strategy could translate into the business, ending up by damaging the company current value or eventually increasing future costs as consequence of the distress. But as mentioned priorly, banks have risk as an inherent component to their activities. Thus, banks should aim for an optimal amount of risk from the perspective of their shareholders. Since an increase in risk could allow banks to increase their investment portfolio, it could also lead to a loss in value putting the bank in financial distress and damaging its ability to create value through liabilities.

In the case of a bank, risk management is an intrinsic activity to the business model as it involves different areas whose impact can affect the banks valuation (DeAngelo and Stulz 2015). Banks are

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<sup>3</sup> risk-taking decisions cannot be individually analyzed but be assessed in terms of their impact on the overall risk of the bank.

required to have risk management practices in place, as this allows them to identify the optimal amount of risk that maximizes the return. Banks should take those projects that increase bank's value, while keeping under control the costs (understood as risks) associated with the project. Unfortunately, as the author Stulz (2014) mentions, risk management for the banking business is a complicated task. Bank's risk management decisions within a financial institution are not isolated, they affect different areas that need to be evaluated to control their impact on the overall risk of the bank. The risk management activity in a bank requires a centralization of the risk monitoring; this centralization can be understood as an individual project risk return contribution to the banks value depending on the banks total risk at the time (Stulz, 2014).

Bank's risk management needs to be a dynamic and holistic practice. Failures can appear when, for example: risk management is done separately by project or when risk management focus only on the risk assumption (putting at risk the business and the revenue of the institution). Risk Management requires uncovering bad risk while keeping in perspective the good risks. Risk Management also requires looking at good and bad risks both from an individual project and the company point of view. It is about finding the right balance between helping the firm to take risks efficiently while ensuring that the risks assumed will not destroy value. This is a critical challenge for the risk management department at any bank. The main risks that affect the bank industry are:

**Credit risk:** tends to be the largest risk for banks. It occurs, consequence of the lending activity, when a borrower fails to fulfil the contractual obligations. Credit defaults can occur at different products, among them: mortgages, loans, credit business lines, credit cards and fixed income securities. Failures to meet obligational contracts can also occur in areas such as derivatives and guarantees provided. Banks need to protect themselves by lowering and diversifying their exposure.

**Market risk** Market risk can be defined as the risk of losses in and on off-balance sheet positions arising from adverse movements in market prices. As the European Banking Authority (EBA) states, market risk can come from all the positions included in banks' trading book as well as from commodity and foreign exchange risk positions in the whole balance sheet

**Operational risk:** can be defined as the risk of losses that arises from inadequate or failed internal processes, people, and systems. It is a risk that does not only affect financial organizations. However, it has gain relevance recently due to the complexity and interdependences of the financial systems and the recent occurrence of extremely large losses.

### **3. Banking crises and systemic banking crises:**

Despite the identification and monitoring, bank risk cannot always be prevented. Thus, an inappropriate development cannot be impeded. When there is an incident which presents significant signs of financial distress in the banking system (namely significant bank runs, losses in the banking system, and/or bank liquidations), we can consider that we are in front of a banking crisis.

Bank's stress tend to be triggered by the decrease in value of banks' assets or by the increase of number of liabilities when the bank has not enough cash for those. When additionally, there are several banks within the same country with problems or when there is a significant banking policy intervention in response to significant losses in the banking system; we can consider that the banking crisis is systemic<sup>4</sup>. The World Bank explains that "a systemic banking crisis is a situation when a country's corporate and financial sectors experience a large number of defaults and financial institutions, and corporations face great difficulties repaying contracts on time." Systemic banking crises can be very

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<sup>4</sup> Laeven and Valencia (2013),

harmful for a country's economy. They usually lead affected economies into deep recessions and sharp current account reversals. In some past cases, systemic banking crises became contagious, rapidly spreading to other countries with no apparent vulnerabilities.

The globalization of the financial system requires a better understanding of the financial linkages, contagion effects and understanding the financial systems of other economies. Capital markets are globalized and hence is the bank's risk assumption. It is pertinent to explain that Systemic risk does not limit to the fields of economy or to financial systems. There are examples across history of systemic risk: from the Great Plague in the Middle Ages to the recent COVID-19 pandemic. However, due to the higher increase of internalization in the capital markets, there are fears that events of systemic nature will become more recurrent. For this reason, it becomes more relevant to study the risk linkages to design political responses that limit the risk widespread.

#### **4. Banks defaults can be contagious across countries and institutions:**

In recent decades, the financial system has grown dramatically, raising the importance of measuring the distress levels. This is not only relevant from a financial stability point of view, but also from a macroeconomic perspective as banking crises have repercussions for the society.

A recent example of the high degree of interconnectedness in the global financial system was observed in the Great Financial Crisis of 2007-09 and the subsequent European Sovereign Debt Crisis. In both cases, financial stress originated in a country quickly spill across borders into different countries and regions.

An additional reason for the constant study and monitoring of the banking risk is that the increasing complexity of the global banking system has made the measurement and monitoring of the banking risk challenging.

## **5. Banks are managed by people:**

### **- How moral suasion and shareholders expectations translate into risk for the financial system-**

It is due to bank's complexity and financial systems interconnectedness that the need for monitoring, prudential regulation and supervision of financial institutions have gained relevance. Financial regulation aims to reduce bank's excessive risk to avoid capital shortages and to protect society. Additionally prudential regulation also tries to identify the origin of financial distress in advance, to allow supervisors to have an early intervention to troubled institutions. With these activities, it is expected to contain the impact that distress has on a financial institution and by extension on the financial sector. The Bank of International Settlements (BIS) defines early supervision as the supervisors that acts at an early stage to address "unsafe and unsound practices or activities that could pose risks to banks or to the banking system."

As a response to the Great Financial crises, the regulators had the determination to strengthen the resilience of the banking system. One of the ways to achieve this aim was by reducing the financial system leverage. One way this can be done is by asking the shareholders to turn down high leverage as a source of high returns on equity. Historically, the average return on equity of the banking industry has been in line with other sectors of the economy. However, to achieve these returns it has been required financial institutions to heavily leverage their balance sheet. And this has been excessive in comparison with the non-financial firms; as Caruana (2012) indicates, during the period 1995–2010 bank's equity was on average leveraged more than 18 times while equity of non-financial firms was leveraged only three times. It can be seen this leverage as one of the reasons behind the volatility of bank profits and the reason why the wins of the "sunny days" do not compensate for the badly performance on "rainy days." For this reason, different regulators try to motivate banks to get returns in a more sustainable way than through leverage.

Another source of perverse incentives for banks to assume undesirable risk, can be found at the financial institution's country government. There is a very interesting phenomenon, substantially analyzed in the literature called "moral suasion". The authors Ongena et al (2019) define moral suasion as the pressure a government (under fiscal stress) does upon local banks to increase the holdings of domestic bonds. The incentives for both parts are as follows; on the one hand governments will benefit from being able to roll over their debt without increasing their financing costs while at the same time they increase their credibility in the money markets. On the other hand, banks -mostly those who have long-term debt holdings- benefit from avoiding a depreciation of the assets they are already holding in their balance and by future favors (the expected favors in return from their "patriotic" duty to help the government under pressure).

## **6. Regulation review:**

When we analyze the regulation, we can observe its organic character. The different banking crises have shown flaws of the regulatory system and motivated its enhancement. The Basel Committee, which was initially called the Committee on Banking Regulations and Supervisory Practices, was founded by the central bank Governors of the Group of ten countries at the end of 1974. This foundation was in part a response to the international currency and banking market turbulences triggered partially by the failure of Bankhaus Herstatt in western Germany (Goodhart, 2011).

Currently the Basel Committee on Banking Supervision (BCBS) is constituted by forty-five institutions in twenty-eight jurisdictions. The Committee is the primary global guidance provider for the prudential regulation of banks. It aims to enhance financial stability by improving the quality of banking supervision worldwide. At the same time, the committee aims to support regular cooperation for banking supervision (BSBS, 2016). Since its foundation one of the Committee's purposes was to close gaps in international supervisory which led to a set of guidelines for financial regulators.

### **6.1.1 Regulation background**

#### 6.1.1.1 Basel I: The Capital Accord

The Basel I commitment was the first step to address the regulation in international banking. The first accord was published in 1988, establishing as essential a minimum ratio of capital to risk-weighted assets of 8% to be implemented by the end of 1992. The main objective of this regulation was to address credit risk. One of the main drivers was the onset of the Latin American debt crisis heightened the Committee's concerns that the capital ratios of the main international banks were deteriorating at a time of growing international risks.

The accord was projected in a dynamic way with the pretention to evolve over time (Goodhart, C 2011). In fact, in November 1991 the committee more precisely defined the general provisions for general loan loss reserves that were included in the capital adequacy calculation. The introduction of capital requirements for market risk was motivated by the collapse of Barings in 1995. This bankruptcy evidences the significance of market risk exposure for banks. Consequently, another change was included in the regulation in April 1995 to provide better recognition of derivative products, bilateral netting effects on banks' credit exposures and to expand the matrix of add-on factors.

In January 1996, a new contribution regarding Market Risk was introduced, an Amendment to the Capital Accord to incorporate market risks or Market Risk Amendment (BSBS, 1996) which took effect at the end of 1997 and allowed banks to use internal models (value-at-risk models). This change had as a purpose of incorporating within the Accord a capital requirement for the market risks arising from banks' exposures to foreign exchange, traded debt securities, equities, commodities, and options. In April 1996, the committee introduced a subsequent change related to netting and with the purpose of identifying the effects of multilateral netting.

#### Deficiencies

Still Basel I suffered from some scope limitations mostly regarding Market and operational risk.

### 6.1.1.2 Basel II

The committee released a revised capital framework in June 2004 which is also known as the accord Basel II (BSBS, 2004). In this accord, the structure of capital regulation framework was increased, Basel II intended to improve the way regulatory capital requirements reflected the real underlying risks and to better address the recent financial innovation. The accord was based on three main pillars: the minimum capital requirements, the supervisory reviews of financial institutions capital adequacy and the use of disclosure as a technique to strength market discipline and sound banking practices.

In Basel II accord the Committee also started to look at the trading book from previous focus on the banking book. Jointly with the International Organization of Securities Commissions<sup>5</sup> (IOSCO) the Basel committee published The Application of Basel II to Trading Activities and the Treatment of Double Default Effects which is a document which states the treatment of banks' trading books under the new framework.

#### Deficiencies

The Basel II accord presented some problems due to an ambiguous definition of the boundary between banking book and trading book. This ambiguous definition left space open for the implementation of regulatory capital arbitrage, to reduce regulatory capital buffer for unexpected losses. Additionally, the capital for the banking system seems insufficient as banks themselves determined the risk drivers used in their models to calculate market risk.

### .1.1.3 Basel II.5 (revision of Basel II)

Basel II.5 was a revision of Basel II norms. Even before the collapse of Lehman Brothers it had become evident for the Committee the need for a regulation reform. The financial system was highly leveraged

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<sup>5</sup> International body of securities regulators

and with inadequate liquidity buffers when the fiscal crisis of 2008 hit. Additionally, the financial system had insufficient governance and risk management with inadequate incentive structures.

As an answer to the existing situation and after the Lehman Brothers collapse the Basel Committee published the principles for sound liquidity risk management and supervision (BSBS, 2008) which was a package of documents to strength Basel II capital framework. These changes were part of a larger package which aimed to increase the regulation and supervision of banks internationally.

#### Deficiencies

As indicated above, one of the issues in Basel II and its revisions was the limit between banking and trading book. The revision by Basel II partially amended Basel II flaws.

#### 6.1.1.4 Basel III

In September 2010, the Group of Governors, and Heads of Supervision<sup>6</sup> (GHOS) established higher global minimum capital standards for commercial banks. In December 2010, the Basel Committee agreed on new capital and liquidity standards which were embodied in Basel III: International framework for liquidity risk measurement, standards, and monitoring (BSBS, 2008) and a global regulatory framework for more resilient banks and banking systems (BSBS, 2011). One of the objectives of Basel III was to reduce the variability of risk-weighted assets (RWA) as during the financial crises' stakeholders questioned the capital ratios reported by banks (Le Leslé and Avramova; 2012).

Basel III reforms focused on aspects such as the calculation of capital requirements for credit risk, credit valuation adjustment risk and operational risk. The reforms also consisted of a revised leverage ratio, a leverage ratio buffer for global systemically important banks and an output floor, based on the

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<sup>6</sup> The oversight body of the Basel Committee on Banking Supervision

revised standardized approaches, (to limits the use of banks internal models to reduce risk-based capital requirements).

#### Deficiencies

Despite not specifically addressing any flaw of Basel III, future changers are unavoidable due to the inevitability of the banking crisis. As Stefan Ingves in his quality of chair Chairman of the Basel Committee explained <sup>7</sup> The Basel Committee needs to be valiant for emerging conjunctural and structural risks to mitigate crisis impacts and supervise how banks react to post-crisis reforms.

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<sup>7</sup> Ingves (2018). Basel III: Are we done now? [Speech transcript]. Basel Committee on Banking Supervision. <https://www.bis.org/speeches/sp180129.htm> (published 29 January 2018)

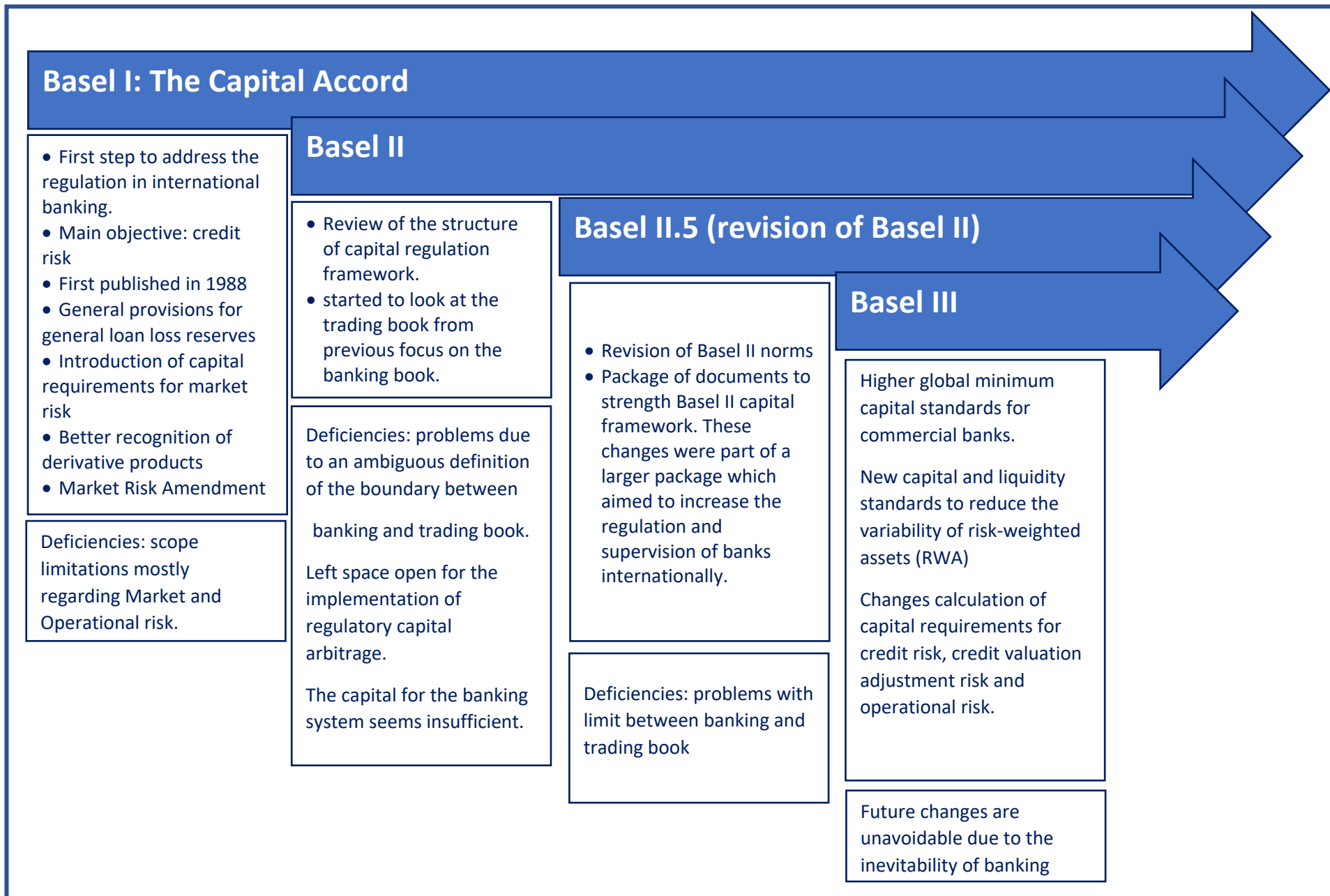


Figure 1 Timeline of the Basel Framework Development

## **7. Outline of the report:**

As we can conclude from the previous section, regulation has the need to evolve. Usually regulatory flaws manifest after and/or during the different banking crises. The banking business and more in particular the risk management and the prevention of banking crises required us to observe the history, learn from prior mistakes and question any pre established idea that help us to understand the dynamic movement of banks.

There is need for ongoing work and research to identify and understand distress, its sources and how to monitor and intervene to decrease the probability of a bank failure. It is within this framework of prudential supervision where the following dissertation can be placed. Recent crises evidenced the need to review how banks operate and the revision of regulatory frameworks. These reasons motivate me to try to add value understanding; Firstly, to inquire the conditions that could drive different economies in the Latin America region to undesirable risk levels. More in particular to identify what are the factors that should raise risk alerts in economies which have been object to dramatic banking crises in the past. Secondly, what are the , the explanatory causes that make the small European banks to increase risk exposure through the purchase of the Sovereign bonds. Thirdly and lastly what are flaws that can be observed in the upcoming regulation for banks to protect against market risk.

Across literature different authors have put their focus on risk factors. While some research has focused on the macroeconomic or regulatory factors that have caused distress to the financial systems, other studies have analyzed the microeconomic factors. The structure of the thesis follows a funnel structure. First, we look at the factors that affect the risk assumption in the Latin America region. Subsequently we look at the link between sovereign risk and bank risk and we analyze the factors that motivate the investment in sovereign bonds for small European banks. Finally, we dig internal banking modelling looking at the way the banks measure risk and the potential “deficiencies” or space for capital arbitrage that the regulation allows banks.

Across this dissertation you will find a clear link between my practitioner career and my research. Research is the tool to create scientific knowledge and to also study, in this case, banking reality. With this thesis I have tried to do a linkage between my academic and practitioners' approach. While the questions that initiated the investigation might have arisen from a practical approach, the subsequent analysis and research follow the academic standards. It might sound illusory but with my work I hope to be able to show how academic research and banking practices are hand in hand. I hope the reader of this work can see the importance that for risk into the financial sector has to understand the questions from an academic point of view keeping standards and not letting the analysis be affected by the market trends.

# 2

## Essay 1

# Bank Risk Determinants in Latin America

## Synopsis

This paper was the first one developed during my doctoral program. When I started the program, I was living in Brazil and working with financial institutions from Central and South America. This experience allowed me to have exposure to the banking system and its regulatory framework from Mexico to Chile. It is due to this professional experience that I familiarized myself with the banking reality of prior crises and the distress the region experienced in recent years; the hyperinflation period in Brazil, the tequila Crisis, and the default of Argentina for example. These crises affected the economies, the populations and the way banks conducted business. Individuals would share stories about how the dysfunction of the financial system during the turbulent times impacted their lives. It was personally shocking to discover that banks faced difficulties in Brazil even when the periods of hyperinflation ended. Given my European background, I was surprised to learn how poorly local regulations were constructed and/or applied and how central bank supervision and interventionism impacted the economies of the region.

The starting point of this paper was to understand the factors behind the banking risk in the region given that these countries have experienced several systemic banking crises since the early 80's. The best-known crises create a particularly interesting for the analysis: Argentina (1980-1982, 1989-1991, 1995, 2001-2003), Chile (1981-1985), Colombia (1982-1982, 1998-2000), Brazil (1990-1994, 1994-1998), Mexico (1981-1985, 1994-1996). While there is plenty of literature of banking risk factors from other regions, we wanted to further expand the research by looking at Latin America as a whole. Giving us the ability to compare the different risk factors of the banks in the region with other economies and financial systems.

The focus of this paper is to understand what drives bank risks in the Latin America region. We want to understand under which paradigm banks reach undesirable levels of risk and we want to identify

which factors could indicate an increase in risk. With this paper we aim to help financial supervisors to quickly detect potential bank crises and pre-emptively intervene in distressed financial institutions. The risk factors of banks which we focus our attention throughout this paper are: leverage levels, credit risk, liquidity risk, profitability and operational risk.

# Bank Risk Determinants in Latin America

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**Abstract:** Systemic Banking crises are a recurrent phenomenon that affects society, and there is a need for a better understanding of the risk factors to support prudential regulation and reduce unnecessary risk intake in the financial system. This paper examines the main bank risk determinants in Latin America. The period analysed covers the timespan from 1999 to 2013, including the systemic banking crisis episodes in Argentina (2001–2003) and Uruguay (2002–2005). We apply a new data-driven comparable methodology to classify and select commercial banks from the sample. We study bank risk proxied by the Z-score. We use the system-GMM estimator as our main empirical analysis method. According to our results, well capitalized, liquid, and traditional commercial banks are less risky. We perform robustness tests by applying OLS, and the results resemble our original model.

**Keywords:** Latin America; financial risk and risk management; banks and depository institutions; bank risk management; emerging markets

**JEL Classification :** G21; G32; L11

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## 1. Introduction

Banking crises and banking regulation are recurrent topics in the economic policy debate. Since the early seventies, banking crises have frequently affected developing and transitioning economies to a greater extent than others (Caprio and Klingebiel 1997). Nonetheless, there is a lack of understanding of the factors that generate banking crises. Regulators tend to assist, more than to resolve the causes of, insolvent institutions (E.J. Kane 2016). Prudential regulation aims to reduce excessive bank risk-taking and capital shortages in an attempt to protect society (E. J. Kane 2016). Unfortunately, these controls tend to arrive too late, after a crisis is already spreading. Therefore, a better understanding of the risk factors could be helpful in further reducing risk, mainly when regulators' powers enable authorities to address situations of distress before they spread to the wider financial system (Schich and Byoung-Hwan 2010).

In this paper, we study the determinants of bank risk in Latin America. Although several studies have focused on bank risk determinants such as capitalization, asset and management quality, profitability, and liquidity (Araújo and Leao 2013; Altunbas et al. 2007; Eichengreen and Rose 1998; Goldstein et al. 2000; Aldasoro et al. 2018; Mäkinen and Solanko 2017), their results are inconclusive, which implies the need for further research. Moreover, we focus on the Latin American banking sector, the particularities of which create an interesting case study. Rojas-Suárez and Weisbrod (1996) show that banking crises in Latin America are different from those in the developed world. For instance, Latin American markets are highly concentrated, and possess significant barriers of entry that might increase the risk of financial distress (Enoch et al. 2016). In highly concentrated banking systems, the collapse of a banking institution can cause distress in the entire financial system. The five largest banks in South America hold three-quarters of the total banking assets of the region (BIS 2007). Agnoli and Vilan (2008) show that banking systems in Latin America have higher concentrations and market power than European and Asian banking systems. Another key issue is the way banking crises are managed; Laeven and Valencia (2012) showed that banking crises in developed countries tend to apply macroeconomic policies, while the bank restructuring approach<sup>8</sup> is more popular in developing countries. An additional peculiarity of Latin American economies is inflation and hyperinflation, which influences the banking sector, financial leverage, and financing sources. Latin American banks have experienced distress after the stabilization of inflation. Financial intermediaries profit from float of payments in scenarios of chronic high inflation, meaning that when the inflation is reduced, a source of income disappears (Demirgüç-Kunt and Detragiache 1998). Finally, Latin America has a special pressure from rising interest rates due to financial risks and market volatility (Enoch et al. 2016). Additionally, risks persist in the form of possible changes in US policies, principally those towards greater trade protectionism or

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<sup>8</sup> Bank restructuring is a process that incorporates a series of measures—namely, macroeconomic, microeconomic, institutional, and regulatory—taken to restore problem banking systems (Sheng 1996).

those that increase the risk aversion of investors, which is a consequence of the tighter financial conditions of international markets (Banco de España 2017).

This paper contributes to the literature on three main aspects. First, we analyze the microeconomic factors of the Latin American banking crises. This work complements previous literature by analyzing the main bank-specific risk determinants, controlling for macroeconomic and regulatory variables. Banking crises in Latin America have mainly been analyzed from a macroeconomic perspective, focusing on the risk intake due to the foreign capital inflows, the impact of foreign institutions, currency crises, or sovereign debt crises (Enoch et al. 2016; García-Herrero 1997; A. Galindo et al. 2010). However, little research has been conducted on the effects of bank-specific variables on the risk of Latin American banks, with the exception of Rojas-Suarez (2001), and Pellegrini et al. (2019). Additionally, Latin American financial systems exhibit differences that make it impossible to extend the conclusions from other regions' analyses. Second, we add clarity to the impact of different indicators on the risk of financial institutions. Even though there is agreement on the identification of banking risk factors, there is an open discussion on the direction of the impact. Finally, we use the generalized method of moments (GMM) estimator developed for dynamic panel models by Arellano and Bover (1995) and Blundell and Bond (1998). This allows us to control for unobserved heterogeneity, as well as for endogeneity. This technique has not been applied on the analysis of the Latin American banking system. Additionally, we apply a recently defined analysis to classify commercial banks across the region.

Our results show a negative relationship between the capitalization, asset quality and liquidity of a bank and its risk, suggesting that well capitalized, liquid, and traditional commercial banks tend to be less risky. Our results are of interest for regulators and policy makers in scenarios of uncertainty and expected economic recession due to the COVID-19 pandemic.

The remainder of the paper is structured as follows. We provide a review of the related literature in the following section. In Section 3, we provide the data analysis; and in Section 4, we show our main results and provide a further discussion.

## **2. Literature Review and Research Hypotheses**

There are differing approaches to studying the determinants and leading indicators of banking crises in the literature. Some authors, e.g., (Eichengreen and Rose 1998; Kaminsky and Reinhart 1999), focus on macroeconomic shocks, while some others, e.g., (Kaminsky and Reinhart 1999), examine the macroeconomic factors (e.g., the ratio of domestic credit to nominal GDP, the real interest rate on deposits, the ratio of lending-to-deposit interest and the deficit as a percentage of the GDP, among others). In emerging markets, banking crises are associated with four main macroeconomic factors: macroeconomic volatility (e.g., large relative price changes, trade fluctuations, interest rates, and changing capital flows), connected lending, government involvement and the failure of prudential regulation (Eichengreen and Rose 1998).

The recent literature analyzing banking crises complements the previous analysis by considering both bank specific and macroeconomic variables, e.g., (Elsinger et al. 2006; Oet and Ong 2011; Lang and Schmidt 2016). Specifically, Elsinger et al. (2006) developed a framework in which they identify that the main sources of systemic risk are the level of correlation of a bank's portfolio exposure, high bankruptcy costs and ineffective crisis resolution strategies.

In recent years, we found large developments in early warning systems that combine macroeconomic and microeconomic variables. For instance, Oet and Ong (2011) included bank-specific and macroeconomic variables to identify imbalances that could be associated with bubbles that explain financial stress (e.g., securitization, the currency exchange rate concentration, bank capital at risk, the

economic value of loan portfolio, leverage, GDP, property, investments, the interest rate, credit to GDP, solvency and credit). This holistic approach can be observed in the recent publications on early warning systems by several central banks, e.g., (Borio et al. 2018; Nyman et al. 2018). In our study, we follow this approach by selecting regulatory, macroeconomic and bank-specific variables. Across the literature we find a broad spectrum of variables that explain bank risk. To conduct a systematic analysis and classification of these variables, we use the CAMEL (Capital, Asset Quality, Management, Earnings and Liquidity)<sup>9</sup> rating system. This rating system was introduced in the 1980s by US supervisors for the on-site examination of banking institutions, and it allows supervisors to assign financial institutions a rating based on different variables. This rating enables comparisons of banks with their peers over time (Stackhouse 2018).

The CAMEL rating is extensively used in the literature, e.g., (Chiaramonte et al. 2015; Stiroh and Rumble 2006; Mäkinen and Solanko 2017). The CAMEL classification is also applied by several international banking supervisors to classify the variables in their Early Warning Systems, e.g., (Lang et al. 2018; Nyman et al. 2018).

Following the CAMEL procedure, we develop five hypotheses.

### **2.1. Capital (Adequacy)**

Capital can be defined as the variable that determines a financial institutions' robustness to withstand shocks to its balance sheet (Gelos 2015). Capital can also be defined as a measure of a bank's sensitivity to difficulties, since the bank's losses end up reducing bank capital (Lang and Forletta 2019). However, there is no consensus on the effect of capital ratios on bank risk. Higher capital requirements are still

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<sup>9</sup> This system allows the supervisors to gather information in a systematic way that will result in the evaluation of bank financial conditions. The CAMEL rating is a uniform rating system, which covers five categories of banks' general conditions to be examined (Capital, Asset Quality, Management, Earnings and Liquidity) (Stackhouse 2018). Within each category or component there is a rating system from 1 to 5 to measure the level of impact that this risk component can have on the bank: 1 represents the highest rating and the lowest level of supervisory concern, while 5 represents the most critically deficient level of performance and therefore the highest degree of supervisory concern.

under debate, as there is no agreement as to how capital changes could affect the likelihood of a new crisis (D'erasmo 2018).

Recent literature shows a negative relationship between a bank's capital and its risk, i.e., (Laeven et al. 2016; Acosta-Smith et al. 2018), supporting the Basel Accords<sup>10</sup>. Acosta-Smith et al. 2017 state that higher capital requirements create more stable and resilient banks, while Laeven et al. (2016) provide empirical evidence that better capitalized banks tend to have lower risk, with this effect being more pronounced for large financial institutions.

Some authors are more critical of the Basel criteria, which they consider to be excessively reductionist. In this vein, Hughes and Mester (1998) state the need to also consider bank efficiency when looking at capital and risk, suggesting that more efficient banks should be allowed to have more flexibility with respect to their capitalization. Similarly, Calem and Rob (1999) show a non-linear (U-shaped) relationship between capital and risk, suggesting that imposing stricter regulatory requirements on banks is a good strategy for regulators only if banks hold a relatively low amount of capital. In contrast, if banks are already highly capitalized, an increase in capital would lead to a higher risk exposure. Schliephake (2016) confirms that capital requirements seem to reduce risk unless banks operate in a highly competitive environment during and in the aftermath of a crisis. In such a scenario, stricter capital requirements could increase bank risk exposure.

Finally, Gelos(2015) and (Nguyen et al. 2019) found a positive relationship between bank capitalization and risk. Gelos (2015) stated that the bank capital ratio can also be used to explain the propagation

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<sup>10</sup> The Basel III Accords require national authorities in each jurisdiction to monitor credit growth and make assessments of whether such growth is excessive. When this credit growth is disproportionate, banks will be required to have a buffer of capital (the so-called countercyclical capital buffer) to achieve the broader macroprudential goal of protecting the banking sector from periods of excess aggregate credit growth that have often been associated with the build-up of system-wide risk. This buffer ensures not only that individual banks remain solvent through a period of stress, but also that the banking sector in the aggregate has the capital on hand to help maintain the flow of credit in the economy.

speed of distress across financial institutions. Likewise, (Nguyen et al. 2019) suggested that larger capital ratios could induce banks to increase risk.

Although in emerging economies capital requirements have not limited risk intake during expansion cycles (Rojas-Suarez 2001), it is necessary for Latin American banks to hold capital to cope with the volatility of the depositors' demands. Latin American banks can use capital reserves as liquidity buffers for these moments in which the risk increases because of the increase in depositors' demands due to special market volatility (Rojas-Suárez and Weisbrod, 1996).

Usually, Capital Adequacy is measured through reversed leverage proxies, e.g., (López 1999; Stackhouse 2018; Bornemann et al. 2014). Therefore, we select the ratio Equity to Total Assets (E/TA) as a proxy for Capital Adequacy (Uhde and Heimeshoff 2009; Chortareas et al. 2011). As equity decreases, with total assets remaining constant, the proportion of debt of a bank will rise, causing higher leverage and increasing their risk (Federico and Vázquez 2012). Therefore, we state the following:

**Hypothesis 1 (H1).** *There is a negative relationship between capital adequacy measured through the E/TA of a bank and its risk.*

## **2.2. Asset (Quality)**

According to the Federal Deposit Insurance Corporation<sup>11</sup>, asset quality measures “the quantity of existing and potential credit risk associated with the loan portfolio, other real estate owned and other assets, as well as off-balance sheet transactions”.

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<sup>11</sup> <https://www.fdic.gov/>.

Assets can be affected by the market valuation and other risks (i.e., reputational, compliance or strategic risk), which can affect the assets' pricing (Rono and Traore 2018). There is a broad consensus concerning the existence of an inverse relationship between a bank's asset quality and its risk (Agresti et al. 2008).

In the literature, we can find different measures of asset quality, such as the following examples: non-performing loans to total gross loans, the sectoral distribution of loans to total loans, and the share of loan loss provisions to total average loans (Betz et al. 2013). Due to the limited data on non-performing loans, we use Net Loans to Total Assets (NL/TA) as a proxy of asset quality. As we will develop in more detail in Section 3, our sample is constituted only by commercial banks, which tend to decrease lending to improve solvency ratios (Maurin and Toivanen 2012).

Another reason to use the NL/TA ratio as a proxy of asset quality is to analyze the lending focus of the institution in comparison to the overall business. Based on recent experiences, it is not necessarily beneficial for commercial banks to venture into non-traditional businesses (e.g., pensions, insurance, asset management, and investment banking, among others) to increase their profitability. Well-known commercial banks such as NatWest, Barclays and Deutsche Bank failed in these ventures and finally returned to their original retail business. We support Miller (1998), who states that the idiosyncrasies of each business should make commercial and investment banking separate.

Poor asset quality in a bank will lower interest income, increase provisions, and affect the regulatory capital of a bank (Baudino et al. 2018). An increase in a bank's regulatory capital will affect its profitability and, by extension, the bank risk. Thus, we hypothesize the following:

**Hypothesis 2 (H2).** *There is a negative relationship between the asset quality (NL/TA) of a bank and its risk.*

### **2.3. Management (Quality)**

Management measures the performance of the individuals in leadership roles at a bank. Regulators expect a bank to operate in a safe and sound manner, promoting a culture of compliance (Stackhouse 2018).

Senior management and the board of directors, to a large extent, are responsible for the financial soundness and performance of the financial institution. Regulators aim to strengthen the quality of the management team responsible for oversight of the bank as it is relevant factor in the process of risk management. Regulators have standards for banks manager in place to be fulfilled (Greuning and Bratanovic 2009).

Management is proxied in the literature by the characteristics of board-members, the CEO, and the chairperson, but also by quantitative ratios such as the cost to income ratio, earnings, the interest margin, and efficiency, among others (Petropoulos et al. 2017; Demsetz and Strahan 1997; Stiroh and Rumble 2006).

We use the Cost to Income ratio (CostI) to measure the management efficiency (BIS 2017; Francis 2014). More efficient banks tend to have lower average costs and lower cost-to-income ratios (Huljak et al. 2019), which are further expected to reduce the probability of a bank failure (Betz et al. 2013). Banks with higher costs and lower levels of efficiency may be tempted to take on higher risks to compensate for the lost returns (Altunbas et al. 2007). Thus, we hypothesize the following:

**Hypothesis 3 (H3).** *There is a positive relationship between “bad quality” management measured through Costl and a bank’s risk.*

#### **2.4. Earnings**

Earnings and profitability indicators are used to assess the financial health and monitor the efficient allocation of a bank’s resources (Agresti et al. 2008). Banks that lose money over significant periods of time do not remain in business. Like other firms, banks do not stay in business unless they are profitable (Stackhouse 2018). Subsequently we can consider that more profitable banks have less propensity to undertake risk-taking incentives (Jensen and Meckling 1976).

However, during the recent financial crisis (2008), some highly profitable financial institutions proved to have engaged in risky investments. Martynova (2015) showed that highly profitable banks may have incentives to take on risky investments, as they can borrow greater amounts, thus accumulating larger risks. Another incentive for profitable banks to assume more risk is due to the lack of competition. Banks with a dominant position in the market can engage risk in alternative activities (Boyd and De Nicoló 2005; Carlson and Mitchener 2006; Calomiris and Haber 2013). An increase in bank competition could lead to a more expensive cost of capital, which could encourage risk taking (Altunbas et al. 2007; Lee and Hsieh 2013). Banks need stable and increasing profits. To obtain stable profitability, a bank must manage its risk, capital, and profitability to develop a business that augments capital resources over time (Greuning and Bratanovic, 2009).

Some common metrics to proxy this category are the return on assets, the return on equity, e.g., (Altunbas et al. 2007; Lee and Hsieh 2013), interest margin to gross income, or non-interest expenses to gross income, e.g., (Agresti et al. 2008; Petropoulos et al. 2017). To measure Earnings, we use the Return on Equity (ROAE). This ratio measures the profitability of a bank’s assets.

For our fourth hypothesis, we state the following:

**Hypothesis 4 (H4).** *There is a negative relationship between bank profitability measured by ROAE and its risk.*

## **2.5. Liquidity**

Liquidity is related to the fundamental maturity transformation mission of a bank, which consists of transforming deposits and other liabilities into loans. Since the maturity of deposits and loans can differ, the bank needs to manage its liquidity by meeting deposit outflows while at the same time satisfying the demand for loans (Stackhouse 2018). However, during the recent financial crisis of 2008, when the European Central Bank (ECB) cut interest rates to below zero—making it expensive for banks to have deposits at the central bank—banks allocated the liquidity to assets, which increased the home-bias risk. This was particularly the case for banks with a high share of retail deposit funding and/or located in lower-rated countries (Macchiarelli 2018).

Petropoulos et al. (2017) and Köhler (2012) measure liquidity by comparing loans to different types of assets (e.g., loans to customer deposits, loans to total assets, and loans to volatile liabilities). Furthermore, Federico and Vázquez (2012) used the liquidity coverage ratio to show the relationship between a bank's dependence on short-term funding to finance the expansion of their balance sheet and their risk. Additionally, Greuning and Bratanovic (2009) determined that the liquidity risk of a bank is related to the bank's dependence on limited sources of funding.

Similar to Petria et al. (2015) and Federico and Vázquez (2012), we proxy liquidity using the Loans to Customer Deposits (L/CD) ratio. Petria et al. (2015) and Federico and Vázquez (2012) showed that banks with a dependence on short-term funding to finance their balance sheet in the period prior to a crisis are more likely to fail during the crisis. A bank with an L/CD ratio above 100% is financing its loans with wholesale funding. Wholesale funding is less stable than customer deposits and could trigger an

increase in the bank's funding liquidity risk (Bonfim and Kim 2012). Therefore, our last hypothesis posits the following:

**Hypothesis 5 (H5).** *There is a positive relationship between the "illiquidity" of a bank as measured by its L/CD and its risk.*

Although previous results of the bank risk determinants remain inconclusive in the literature, based on the previous analysis, and taking into consideration that we are focusing on commercial banks located in Latin America, we expect well-capitalized, loan-focused (traditional bank), well-managed, profitable and liquid banks to have better Z-score ratios, and, consequently, lower risk.

### **3. Data and Methodological Aspects**

#### ***3.1. Sample selection***

We chose banks based on the available data in the Bankscope database maintained by Bureau Van Dijk (now Orbis Bank Focus). To minimize any incoherence and possible bias related to the bank business idiosyncrasies, we included only commercial banks in our sample. Moreover, to limit the potential for selection bias, we included banks that ceased their activities and others that might have changed their name due to an acquisition or further structural changes in the sample.

The range of the period we covered was from 1999 to 2013, which includes the crises in Argentina from 2001 to 2003 and in Uruguay from 2002 to 2005. The countries selected were the sovereign states categorized as Latin America (see Table 1). Nevertheless, four countries could not be included, since there was no information about their banks (Cuba, El Salvador, Haiti and Nicaragua).

Entities with abnormal ratios or extreme values were eliminated from the sample as outliers. The criterion used to remove observations was that they were below the lower bound or above the upper

bound. The formula for the lower bound was  $Q121 - 1.5 * IQD13$ . The formula to calculate the upper bound was  $Q3 + 1.5 * IQD$ .

**Table 1.** Distribution of the observations across countries.

Country	Observations	% of Observations per Country
Argentina	1500	11.22%
Bolivia	255	1.91%
Brazil	3165	23.68%
Chile	780	5.84%
Colombia	1185	8.87%
Costa Rica	690	5.16%
Ecuador	420	3.14%
Guatemala	615	4.60%
Honduras	390	2.92%
México	885	6.62%
Panama	1590	11.90%
Peru	540	4.04%
Uruguay	510	3.82%
Venezuela	840	6.29%

Source: Authors' own. Data source from Bureau Van Dijk (Van Dijk and Fitch 2013).

### **3.2. Business Model Classification**

We used the Bank for International Settlements (BIS) Bank business model classification (Roengpitya et al. 2014) to select only retail-commercial banks. All banks from the sample needed to fulfil specific conditions to be classified as “commercial”. Following Roengpitya et al. (2014), we selected those banks from our sample with ratios of growth of gross loans to growth of total assets, deposits to total assets, and stable funding that were higher than those from trading banks (a trading bank would have ratios of approximately 25.5%, -38%, and 48.6%, respectively). Additionally, we chose banks with proportions of Interbank Lending to total assets divided by Interbank liabilities to total assets and

<sup>12</sup> Quartile.

<sup>13</sup> Interquartile Distance Q1–Q3.

Trading to total assets that were lower than the ratios of trading banks (a trading bank would have ratios of approximately 21.8%, 19.1%, and 17.3%, respectively).

### **3.3. Variables**

#### 3.3.1. Dependent Variable

The Z-score is our primary measurement of an individual banks' risk. The Z-score measures the distance to default of a bank from an accounting point of view and the inputs to the calculation are the return on assets and the volatility of the return on assets. The higher the Z-score ratio is, the greater the distance to default and, consequently, the lower the risk; conversely, the closer the Z-score is to zero, the higher the risk and the greater the probability of default. Therefore, the Z-score is indirectly proportional to bank risk.

It is common in the literature to use the Z-score to measure bank risk (Maudos 2017; Uhde and Heimeshoff 2009; Ravi and Ravi 2007). Recently, Sherbo and Smith (2013) analysed the Z-scores of the financial crisis period (from December 2007 to June 2009), proving that this risk measurement is significant with 99% confidence.

We calculate the Z-score as follows:

$$Z - score_{i,t} = \frac{ROAA_{i,t} + ETA_{i,t}}{\sigma(ROAA)_{i,t}}$$

where  $ROAA_{i,t}$  represents the return on average assets of bank  $i$  in year  $t$ ,  $ETA_{i,t}$  denotes the ratio of equity to total assets and  $\sigma(ROAA)$  is the standard deviation of the return on total average assets.

Since the Z-score is highly skewed, we use the natural logarithm of the Z-score (Laeven and Levine 2009; Liu et al. 2013). Cihák and Schaeck (2007) proved that the frame for calculating the Z-score in their sample did not affect their results, and Yi (2012) computed the Z-score for two consecutive periods. Thus, we adjusted the Z-score calculation to use a two-year rolling window to increase the number of observations.

### 3.3.2. Explanatory Variables

As we have previously stated in the Literature review section, we rely on the CAMEL rating system to select our explanatory variables. We present the description of the variables and expected signs in Table 2.

**Table 2.** Variable description.

Classification	Variable	Notation	References
Risk	<i>Z-score</i>	<i>Z-score</i>	Lapteacru (2017); Mercieca et al. (2007); J. Maudos (2017); Sherbo and Smith (2013); Ravi and Ravi (2007); Laeven and Levine (2009); Liu et al. (2013)
Capital	Equity to Total Assets	<i>E/TA</i> %	Federico and Vázquez (2012); Uhde and Heimeshoff (2009); Chortareas et al. (2011)
Asset Quality	Net Loans to Total Assets	<i>NL/TA</i> %	Altunbas et al. (2007); Petropoulos et al. (2017); Betz et al. (2013)
Management	Cost to Income Ratio	<i>CostI</i> %	Chortareas et al. (2011); BIS (2017); Francis (2014); Petropoulos et al. (2017)
Earnings	Return on Avg. Equity	<i>ROAE</i> %	Altunbas et al. (2007); Lee and Hsieh (2013)
Liquidity	Loans to Customer Deposits	<i>L/CD</i> %	Petria et al. (2015); Federico and Vázquez (2012); Köhler (2012); Greuning and Bratanovic (2009)
Bank Concentration	Herfindahl-Hirschman Index	<i>HHI</i>	Uhde and Heimeshoff (2009)
Regulation	Activity restriction index	<i>Ares</i>	Barth et al. (2004) and updates
	Capital stringency	<i>CStr</i>	Barth et al. (2004) and updates
	Official supervisory power	<i>OSP</i>	Barth et al. (2004) and updates
	Private Monitoring	<i>PriM</i>	Barth et al. (2004) and updates
	Domestic credit to the private sector (as % of GDP)	<i>DCPS</i>	Demirgüç-Kunt and updates Detragiache (1998); Kaminsky and Reinhart (1999)
	Real interest rate	<i>Int</i>	Demirgüç-Kunt and Detragiache (1998); Uhde and Heimeshoff (2009)
Macroeconomic	Inflation %	<i>Infl</i> %	Demirgüç-Kunt and Detragiache (1998); Davis et al. (2011)
	Current Accounts	<i>CurrAcc</i> %	Gertler et al. (2012)
	Real GDP growth rate (Annual percent change)	<i>GDP<sub>grow</sub></i>	World Development Indicators (WDI); Demirgüç-Kunt and Detragiache (1998)
Size	Unemployment rate	<i>Unpl</i> %	Bofondi and Ropele (2011); A. Uhde, Uhde and Heimeshoff (2009)
	Total Assets	<i>TA</i>	Kleinov et al. (2014); Boyd and Prescott (1986); Araújo and Leao (2013)

The first CAMEL variable proxy we used for the Bank's Capital was the E/TA. We expected a negative relationship between bank capitalization and the bank risk, since a lower E/TA means higher leverage, which makes the institution less resilient to shocks (Mäkinen and Solanko 2017). In addition, the E/TA ratio is highly correlated with the Basel III regulatory definition of the leverage Ratio (ECB 2016).

Asset quality was examined through the NL/TA ratio, since banks with higher NL/TA ratios should be able to generate more interest revenue (García-Herrero et al. 2009), and bank profitability is a key component to increasing an institution's financial stability (ECB 2016).

The management quality of a bank was measured by CostI. An increase in CostI is expected to increase the probability of a bank failure (Betz et al. 2013; Maudos and de Guevara 2004; Demsetz and Strahan 1997).

To measure a bank's earnings, we used ROAE. We expected a negative sign for the relation between the ROAE and distress, since increased profitability reduces the likelihood of a distress event (Altunbas et al. 2007; Greuning and Bratanovic 2009).

Illiquidity was proxied by the L/CD ratio (Bonfim and Kim 2012). The relationship between the liquidity and bank risk was expected to be negative, since banks that finance their loan portfolios with short term liabilities may be exposed to refinancing problems in scenarios of macroeconomic stress, since in these circumstances banks may find it difficult to raise short-term funds and customer/wholesale deposits, eventually incurring deposit drainages (Chiaramonte et al. 2015).

### 3.3.3. Control Variables

The differences in the economic, political, and regulatory frameworks of countries justify controlling for macroeconomic and regulatory variables in this analysis. Our research approach captures a holistic view of the banking crises considering macro and bank specific variables, which is in line with the research by Lund-Jensen (2012), who found that the level of systemic risk depends on macroeconomic and bank specific factors. Similarly, in their analysis of the early warnings signs of banking crises, Demirgüç-Kunt and Detragiache (1998) found the impacts of macroeconomic factors and that crises tend to emerge in scenarios with weak macroeconomic conditions, including low growth, high inflation, high real interest rates, a vulnerable balance of payments, explicit deposit insurance, and weak law enforcement.

Moreover, Reinhart and Rogoff (2013) concluded that there was a correlation between the peaks in the current account balance and new defaults on sovereign debt. Similarly, Valencia and Laeven (2008) showed that most banking crises occurred in countries with large current account deficits, while Kauko (2012) established that credit growth combined with current account deficits contributed to vulnerabilities in the banking system. Thus, we controlled for Current Accounts (CurrAcc).

We further controlled for Domestic Credit to the Private Sector (DCPS) since it plays an economically and statistically significant role in predicting subsequent crises. Obstfeld (2012) concluded that across all types of crises, the domestic credit to output was identified as the one variable with an important role.

GDP growth is included in most model specifications, irrespective of the geographic location of the banking crisis. Davis et al. (2011) indicated that crises occur in periods during which the GDP growth rate is low and interest rates, inflation and fiscal deficits are high. This idea was reinforced by Demirgüç-

Kunt and Detragiache (1998) who proved that economic growth can be used to predict crises since, in most cases, the GDP growth rate slows down immediately before a crisis.

Chinn and Dooley (1997) analyzed how crises in Latin America were generally preceded by a large foreign speculative capital inflow, which does not necessarily follow interest rate differentials across currencies. Fiscal shocks can increase the destabilization of domestic interest rates, leading to expected inflation and distorting the domestic deposit demand (Gavin and Hausmann 1998). Additionally, in a context with high interest rates, their reduction could induce the banks to lower their lending standards in search of a better yield (Lamas and Mencia, 2019). Therefore, we controlled for the interest rate (Int) in the period studied across the different countries.

In their conclusions regarding how weak macroeconomic conditions affect systemic banking crises, Demirgüç-Kunt and Detragiache (1998) stated that high inflation can be one of the main causes of systemic banking problems. In the same way, Davis et al. (2011) examined how excessive inflation (above 30%) doubles the chances of a systemic banking crisis in Latin America compared to other regions in the world. Finally, Lo Duca and Peltonen (2013) considered inflation to be one of the relevant variables to address country-specific macro financial indicators in the case of emerging economies. We therefore controlled for Inflation % (Infl) in our multivariate analysis.

We further controlled for Unemployment rate % (Unemp), which has been related to bank asset quality in the previous literature (Bofondi and Ropele 2011). A higher unemployment rate may affect the bank risk associated with lending (Hancock and Wilcox 1994).

Finally, we selected four indicators from the World Bank database on Bank Regulation and Supervision developed by Barth et al. (2004) to control for regulatory differences across Latin American countries in our empirical specification, since the literature suggests that these indicators may affect bank risk.

The Activity Restriction Index (Ares) includes restrictions on securities, insurance, and real estate activities, plus restrictions on banks owning and controlling nonfinancial firms. Capital Stringency (CStr) captures whether the capital requirement reflects certain risk elements and deducts certain market value losses from capital before minimum capital adequacy is determined.

Official Supervisory Power (OSP) is connected to whether supervisors have the authority to take specific actions to prevent and correct problems and circumstances that can help to prevent banks from engaging in excessive risk-taking behavior, thus improving bank development, performance, and stability. Private Monitoring (PriM) levels show the degree to which banks are forced by the supervisory authorities to disclose accurate information to the public, and whether there are incentives to increase market discipline. These regulations, which promote and facilitate the private monitoring of banks, are associated with better banking-sector outcomes.

Following Uhde and Heimeshoff (2009), we controlled for Industry concentration using the Herfindahl-Hirschman Index (HHI). In their investigation, Uhde and Heimeshoff (2009) showed that there is a negative relationship between market concentration and European banks' financial robustness.

We further controlled for bank size using the natural logarithm of its total assets (TA). Across the literature, several studies have indicated that larger banks can improve their profitability levels and capital buffers, which decreases their assumed risk intake (Kleinov et al. 2014). Additionally, these banks can benefit from economies of scale and scope (Boyd and Prescott 1986). Araújo and Leao (2013) indicate that larger institutions, as measured through the TA, in Brazil tend to be less risky.

### 3.3.4. Methodology

We applied the GMM-System estimator developed by Arellano and Bover (1995) and Blundell and Bond (1998), which is also referred to as the system-GMM estimator. Since some bank-specific factors of bank risk can be endogenous, some other unobserved characteristics could cause correlations between the coefficients of the explanatory variables. We applied the GMM-System estimator in a two-step estimation procedure with finite-sample corrected standard errors, as proposed by Windmeijer (2005) and Baselga-Pascual et al. (2015).

The system-GMM estimator addresses endogeneity by means of suitable instruments. We consider the bank-specific variables as endogenous covariates by employing the lagged first differences of the bank-specific explanatory variables as instruments for the equation in levels and the lagged values of the explanatory variables in levels as instruments for the equation in differences (in line with Arellano and Bover 1995; Blundell and Bond 1998). Industry concentration and macroeconomic variables are treated as strictly exogenous following the authors Delis and Staikouras (2011) and Baselga-Pascual et al. (2015). Our baseline equation is as follows:

$$Y_{i,j,t} = \alpha + \delta \cdot Y_{i,j,t-1} + \beta \cdot BS_{i,j,t} + \gamma \cdot M_{j,t} + \theta \cdot R_{j,t-1} + \eta \cdot L_{i,j,t} + \varepsilon_{i,j,t} \quad (1)$$

where  $Y$  denotes the variable used to measure the risk of bank  $i$  in country  $j$  at year  $t$ ;  $Y_{i,j,t-1}$  represents the lagged value of the dependent variable;  $\delta$  measures the speed of mean reversion;  $BS_{i,j,t}$  and  $M_{j,t}$  denote, respectively, the bank-specific and the industry and macroeconomic variables considered in our study;  $R_{j,t-1}$  refers to several bank regulation and supervision control variables; and  $\beta$ ,  $\gamma$ , and  $\theta$  are vectors of coefficient estimates. Finally,  $\varepsilon_{i,j,t}$  is the disturbance term.

Additionally, and similar to earlier studies on bank risk, e.g., (Baselga-Pascual et al. 2015; Foos et al. 2010), to increase the robustness of our original results, we alternatively applied the ordinary least

squares (OLS) regression with fixed year and country effects. However, due to the nature and superiority of the system-GMM estimator (it can use lagged values of the dependent variable and capable of treating endogenous, bank-specific variables instrumented by their own lagged values), we will prioritize the results of the GMM-System above those of the OLS.

#### 4. Empirical Results

Table 3 provides the results of the system-GMM estimator. Based on the sign and significance of the coefficients, we can confirm hypotheses 1, 2 and 5.

First, looking at the E/TA, we observe a positive and significant relationship with the Z-score, which indicates that banks with less risk have higher E/TA ratios, as we state in hypothesis 1. This finding is in line with Laeven et al. (2016) and Acosta-Smith et al. (2017), showing that higher capital requirements relate to better capitalized banks, and a more resilient scenario. The Latin American financial system is particularly fragile due to the high volatility in capital inflows experienced in the past, which required the strengthening of capital adequacy requirements<sup>14</sup>. These capital inflows were accompanied by rapid expansions of bank credit and consumption booms which caused contractions and bust when the inflows were reversed (IMF 2015).

Second, we find a negative relationship between the NL/TA and bank risk. Consequently, we can confirm our second hypothesis, showing that asset quality is indicative of more lending and less risk. From this result, we can also conclude that within the commercial banks, a larger portfolio of loans is related to lower risk. This result could indicate that banks focused on the basic activity of maturity transformation tend to have less risk.

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<sup>14</sup> Chile adopted a banking law in 1986 restricting related lending and strengthening capital adequacy requirements. Brazil increased capital requirements for opening new banks. Prudential capital ratios were settled above the Basel minimum by Argentina, Brazil, and Venezuela; IMF (2015).

The fact that, in the past, Latin American banks replaced nonperforming loans with sizable portfolios of government bonds could contribute to explaining the negative relation between NL levels and banks risk. This reaction was caused due to the experience of high default rates from households and corporation lending (IMF 2015). However, government bonds exposure can be risky (BIS 2017). This exposure can hide efficiency issues from banks, as it presents limitations to allocating their resources through maturity transformation. This strategy consists of shifting a bank's portfolio risk towards sovereign exposure to maximize their returns (Gennaioli et al. 2013; Lamas and Mencía 2019).

Finally, illiquidity seems to be positively correlated with the bank risk (negatively correlated with the Z-score value). Thus, we can confirm our fifth hypothesis since the proxy L/CD is statistically significant and positively related to bank risk in the GMM. Less liquid banks, i.e., those with lower proportions of their loan portfolios being financed by customers' deposits, take on more risk. Banks can experience an increase in risk levels when the liquidity levels decline or the proportion of loans to customer deposits increase, which amounts to the same thing. In the past, Latin America has experienced crises of liquidity. Latin American countries are characterized by a relatively high level of dollarization, large shares of bank deposits and loans denominated in dollars (Bolivia, Nicaragua, Paraguay, Peru and Uruguay, more than half of deposits and loans are denominated in dollars) and in some countries dollarization has even instigated currency substitution (Bolivia, Paraguay, Peru and Uruguay). Highly dollarized banking sectors can be characterized by higher insolvency levels and deposit volatility (De Nicolo et al. 2003), which helps to understand the higher proportion of liquidity levels needed by the Latin American banks. In fact, in a scenario of banking distress, depositors have an incentive to convert their deposits into cash and transfer them abroad. This behavior was appreciated during the Uruguayan crisis of 2002 or the effects the Mexican crises of 1994 had in the Argentinian banks (De Brun and Licandro 2006).

We cannot, however, confirm our third and fourth hypotheses. The coefficient of Cost1 is positive, but not significant, and this can be explained by the different cost structures of the institutions across the region. Additionally, the banking structure inefficiency in this area is left over from the high inflation periods. During times of high inflation, banks' revenues obtained from holding government bonds indexed to the overnight interest rate compensate for the deposit rate, which allows banks not to pay enough attention to the efficiency levels, and thus the costs across the region continue being high (Singh 2005). Regarding the ROAE, we cannot confirm our hypothesis 4 due to the statistical insignificance of the coefficient.

Looking at the control variables, we find that the Int rate and the TA are significant. The interest rate seems to be negatively related to banks' risk intake, which can be easily understood due to the idiosyncrasy of the zone, where banks are used to working with high interest rates and larger spreads. In the same way, the TA seems to be negatively correlated with bank risk. In some of the larger economies of the zone, such as Brazil, there has been a consolidation process across the sector, which allows the institutions to achieve economies of scale and scope and become more efficient.

**Table 3.** System-GMM estimators of the *Z-score*.

<b>Variables</b>	<b>Z-score</b>
<i>Constant</i>	112.53 (211.62)
<i>ETA</i>	3.01 *** (1.2)
<i>NLTA</i>	1.67 ** (0.76)
<i>CostI</i>	-0.19 (0.31)
<i>ROAE</i>	-3.39 (2.64)
<i>LCD</i>	-0.24 ** (0.12)
<i>HHI</i>	-289.3 (424.23)
<i>Ares</i>	-10.86 (9.51)
<i>CStr</i>	-0.53 (5.95)
<i>OSP</i>	-2.41 (8)
<i>PriM</i>	-3.24 (14.82)
<i>DCPS</i>	-0.57 (0.82)
<i>Int</i>	2.31 * (1.31)
<i>Infl</i>	0.23 (2.09)
<i>CurrAcc</i>	1.7 (0.81)
<i>GDPgrowth</i>	-0.56 (1.57)
<i>Unemp</i>	-1.66 (4.08)
<i>TA</i>	25.15 ** (12.53)
AR <sub>1</sub>	-1.96
AR <sub>2</sub>	0.95
Sargan	332.39
Hansen	111.74
F	1.90 **
Number of observations	525

Notes: The table reports the determinants of bank risk in Latin America during the period from 1999 to 2013 using the GMM estimator developed by Arellano and Bover (1995) and Blundell and Bond (1998). The risk characteristics are classified using the CAMEL. Table 2 provides a description of the explanatory variables. The bank level variables are considered to be endogenous (*ETA*, *NLTA*, *CostI*, *ROAE*, *LCD*, and *TA*) while the macroeconomic/regulatory are considered to be exogenous (*HHI*, *Ares*, *CStr*, *OSP*, *PriM*, *DCPS*, *Int*, *Infl*, *CurrAcc*, *GDPgrowth*, and *Unemp*). We report heteroskedasticity-consistent asymptotic standard errors in parentheses, and the significance levels are indicated as follows: \*\*\* = significant at the 1% level, \*\* = significant at the 5% level, and \* = significant at the 10% level. Hansen is a test for over-identifying restrictions, which are asymptotically distributed as  $\chi^2$  under the null hypothesis of no correlation between the instruments and the error term. Source Authors' own. Data Source from Bureau Van Dijk (Van Dijk and Fitch 2013).

#### **4.1. Robustness**

To test the robustness of our results, we alternatively applied an OLS regression with fixed year and country effects (see Table 4). The results of the OLS confirm hypotheses 1 and 2, showing significant and negative correlations between capital ratios, asset quality and bank risk, thus providing robustness to our results. However, based on the OLS regression, we cannot confirm hypothesis 5. There are some differences regarding the control variables since TA and Int lose their significance. However, due to the higher accuracy of the GMM-system and the confirmation of hypotheses 1 and 2, we find robust confirmation of the results.

**Table 4.** OLS for *Z-score*.

<b>Variables</b>	<b>Z-score</b>
<i>Constant</i>	49.18 (274.33)
<i>ETA</i>	1.74 * (0.98)
<i>NLTA</i>	1.6 *** (0.61)
<i>CostI</i>	-0.4 (0.31)
<i>ROAE</i>	-1.47 (3.92)
<i>LCD</i>	-0.09 (0.09)
<i>HHI</i>	-101.34 (279.9)
<i>Ares</i>	0.44 (10.5)
<i>CStr</i>	6.52 (7.92)
<i>OSP</i>	-2.75 (9.97)
<i>PriM</i>	-7.1 (13.68)
<i>DCPS</i>	0.9 (1.5)
<i>Int</i>	1.21 (1.04)
<i>Infl</i>	-1.02 (2.4)
<i>CurrAcc</i>	1.15 (0.84)
<i>GDPgrowth</i>	0.17 (2.04)
<i>Unemp</i>	-3.81 (4.13)
<i>TA</i>	10.78 (7.14)
R <sup>2</sup>	0.0105
Number of observations	742

Notes: The table reports the determinants of bank risk in Latin America during the period from 1999 to 2013 using OLS. The risk characteristics are classified using the CAMEL. Table 2 provides a description of the explanatory variables. We report heteroskedasticity-consistent asymptotic standard errors in parentheses, and the significance levels are indicated as follows: \*\*\* = significant at the 1% level, \*\* = significant at the 5% level, and \* = significant at the 10% level. Source Authors' own. Data Source from Bureau Van Dijk (Van Dijk and Fitch 2013).

## 5. Conclusions and Discussion

In this paper, we examine the main bank risk determinants in Latin America. The conclusions of this study are relevant for regulators in their aim to reduce the spread and limit the consequences of financial crises.

This article empirically analyses the factors influencing the risk of commercial banks in Latin America from the period from 1999 to 2013 using a panel data set of 13,365 observations. The period of analysis includes the systemic banking crises in Argentina (2001–2003) and Uruguay (2002–2005). We proxy risk using the measure of the Z-score. The bank risk determinants are classified following the CAMEL Rating. We complement our analysis by controlling for macroeconomic and regulatory variables. Additionally, we perform a robustness check by applying an alternative methodology that provides similar results to our original model.

One innovative factor of our analysis is the classification of the different bank business models in the sample by selecting only commercial banks, following Roengpitya et al. (2014). We further examine the bank-specific, regulatory, and macroeconomic determinants of bank risk and how they affect risk as measured by the Z-score (Maudos 2017; Uhde and Heimeshoff 2009; Ravi and Ravi 2007; Smith 2013). We apply a quantitative approach using the system-GMM estimator, developed by Arellano and Bover (1995) and Blundell and Bond (1998), to analyze dynamic panel models.

Supporting the previous literature, we find a negative relationship between a bank's capital adequacy, asset quality, liquidity, and risk.

According to our results, well-capitalized banks have lower risk. Several authors have shown that banks with strong equity levels are more resilient to shocks (ECB 2016; Gelos 2015). Therefore, it would be desirable, in the light of the Latin American financial markets' fragility, to increase their capital ratios. We further show a negative relationship between the NL/TA and banks. This result might indicate that larger loan portfolios are related to stronger bank health levels, since they are more focused on traditional banking activities (Behn et al. 2019). Our results support the recent regulations in the United

States (the Volcker rule), United Kingdom (the Vickers Commission report) and Europe (the Liikanen report) that imply restrictions on the universal banking model in favor of traditional banking.

Finally, we show that higher levels of liquidity lead to lower bank risk, supporting Petria et al. (2015) and Federico and Vázquez (2012), who identified that mismatched maturity between deposits and loans is a source of risk. Due in part to the dollarization of the economy, the past period of deposit runs, and macroeconomic imbalances, it is relevant to consider high liquidity levels for the Latin American region to mitigate bank risk.

We cannot confirm our third and fourth hypotheses. The different regulatory environments across the banks in our sample could affect CostI, which could explain the lack of significance of this variable. Despite bank profitability in general being associated with bank efficiency and lower risk (TengTeng 2019), we conclude that the same cannot be extended to emerging markets. This finding was also reported by Rojas-Suarez (2001) in her analysis of financial indicators in emerging markets, where she highlights that neither profitability ratio nor the cost ratio are useful indicators for discerning between strong and weak banks in developing countries. These results show that the banks across this region have a specific idiosyncrasy regarding costs, since financial intermediation expenses in the region are particularly high (Calice and Zhou 2018).

With respect to macroeconomic variables, our results show a negative relationship between interest rates and bank risk. Contrary to some European countries, Latin American countries seem to have lower risk intake when higher interest rates exist, which shows the idiosyncrasy of the region and indicates that Latin American banks work better in high interest rates scenarios where they can be more selective in their asset allocation. We further find a negative relationship between bank size and risk.

In conclusion, the risk factors that affect financial institutions in Latin America are relevant topics of analysis since these institutions continue being confronted with significant challenges, including a weak economic environment, currency devaluation and interest rate volatility, that reduce profitability and increase risk.

A better understanding of the risk factors in the Latin American financial sector gains additional interest in the current weak global economy in which the rising policy uncertainty is slowing down Latin America's growth momentum. As a matter of fact, banks and regulators should closely and proactively monitor their financial intermediaries' risk intake in the economic slowdown caused by the tightening of global financial conditions, uncertainty of the COVID-19 pandemic and the commercial tensions in the global trade. As mentioned by the International Monetary Fund (IMF) director Kristalina Georgieva, Latin America has been hit particularly hard, with an expected contraction of 9.3 percent in 2020 (Georgieva 2020), which would doubtless spread to the banks and contribute to region growth.

Due to the chosen analysis approach, this study could present limitations. We focused on the main economic indicators at the bank level across commercial banks. It should be noted that some omitted variables, such as political factors and changes in governments could affect the policies in place and, therefore, bank risk.

**Author Contributions:** M.M.-M. and L.B.-P. conceived the presented idea. M.M.-M. developed the theory and performed the computations. L.B.-P. verified the analytical methods, encouraged M.M.-M. to investigate *Z-score* as the risk measure, and the use of GMM-System as the main methodology and supervised the findings of this work. All authors discussed the results and contributed to the final manuscript.

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## References:

- (Acosta-Smith et al. 2017) Acosta-Smith, Jonathan, Michael Grill, and Jan Hannes Lang. 2018. The Leverage Ratio, Risk-Taking and Bank Stability. ECB Working Paper 2079.
- (Agnoli and Vilan 2008) Agnoli, Myriam Quispe and Diego Vilán. 2008 Financing trends in Latin America. Bank for International Settlements, 36, 15-27.  
<https://www.bis.org/publ/bppdf/bispap36.pdf>.
- (Agresti et al. 2008) Agresti, Ana María, Patrizia Baudino, and Paolo Poloni. 2008. The ECB and IMF indicators for the Macro- prudential analysis of the banking sector: a comparison of the two approaches. ECB Occasional Paper Series, 99.
- (Aldasoro et al. 2018) Aldasoro Iñaki, Claudio Borio, and Mathias Drehmann. 2018. Early warning indicators of banking crises: Expanding the family. BIS Quarterly Review 2018: 29–45.
- (Altunbas et al. 2007) Altunbas, Yener, Santiago Carbo, Edward P. M. Gardener, and Philip Molyneux. 2007. Examining the relationships between capital, risk and efficiency in European banking. *European Financial Management*. 13: 49–70.  
doi:10.1111/j.1468-036X.2006.00285.x.
- (Araújo and Leao 2013) Araújo, Gustavo, and Sergio Leao. 2013. Risco Sistêmico no Mercado Bancário Brasileiro – uma Abordagem pelo Método. Brasília: Banco Central do Brasil.
- (Arellano and Bover 1995) Arellano, Manuel and Olympia Bover. 1995. Another look at the instrumental variable estimation of error-components models. *Journal of Econometrics* 68: 29–51.
- (Banco de España 2017) Banco de España 2017. Financial Stability Report. Bank of Spain: Madrid. Spain.
- (Barth et al. 2004) Barth, James R., Gerard Caprio, and Ross Levine. 2004. Bank regulation and supervision: What works best? *Journal of Financial Intermediation* 13: 205–48.  
doi:10.1016/j.jfi.2003.06.002.
- (Baselga-Pascual et al. 2015) Baselga-Pascual, Laura., Antonio Trujillo-Ponce, and Clara Cardone-Riportella. 2015. Factors influencing bank risk in Europe: Evidence from the financial crisis. *North American Journal of Economics and Finance* 34: 138–66.  
doi:10.1016/j.najef.2015.08.004.
- (Baudino et al. 2018). Baudino Patrizia., Orlandi Jacopo. and Zamil Raihan. 2018 The identification and measurement of non-performing assets: A cross-country comparison. FSI Insights on policy implementation, 7. Bank for International Settlements (BIS).
- (Behn et al. 2019) Behn, Markus, Claudio Daminato, and Carmelo Salleo. 2019. A Dynamic Model of Bank Behaviour under Multiple Regulatory Constraints. ECB Working Paper, 2233. Available online:  
<https://www.ecb.europa.eu/pub/pdf/scpwps/ecb.wp2233~f03ecad4e8.en.pdf>  
(accessed on 18 November 2019).
- (Betz et al. 2013) Betz, Frank, Silviu , Toumas A. Peltonen, and Peter Sarlin. 2013. Predicting distress in European Banks. ECB Working Paper, 1597. Available online:

<https://www.econstor.eu/handle/10419/154030> (accessed on 28 November 2018).

- (BIS 2007) BIS 2007. Evolving banking systems in Latin America and the Caribbean. Bank for International Settlements (BIS). Retrieved from <https://www.bis.org/publ/bppdf/bispap33.pdf> (accessed on 1 June, 2018).
- (BIS 2017) BIS. 2017. The Regulatory Treatment of Sovereign Exposures—Discussion Paper. Bank for International Settlements (BIS) <https://www.bis.org/bcbs/publ/d425.pdf> accessed on 01 June 2018.
- (Blundell and Bond 1998) Blundell, Richard, and Stephen Bond. 1998. Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics* 87: 115–43.
- (Bofondi and Ropele 2011) Bofondi, Marcello, and Tiziano Ropele. 2011. Macroeconomic Determinants of Bad Loans: Evidence from Italian banks. *Bank of Italy occasional papers*, 89.
- (Bonfim and Kim 2012) Bonfim, Diana, and Moshe Kim. 2012. Liquidity Risk in Banking: Is There Herding? EBC Discussion Paper, 2012-024. ECB.
- (Borio et al. 2018) Borio, Claudio, Piti Disyatat, Mikael Juselius and Phurichai Rungcharoenkitkul. 2018. Monetary policy in the grip of a pincer movement. *BIS Working Papers* 706.
- (Bornemann et al. 2014) Bornemann, Sven, Susanne Homölle, Carsten Hubensack, Thomas Kick, and Andreas Pfingsten. 2014. Visible Reserves in Banks Determinants of Initial Creation, Usage and Contribution to Bank Stability. *Journal of Business Finance & Accounting* 41: 5–6.
- (Boyd and De Nicoló 2005) Boyd, John. H., and Gianni. De Nicoló. 2005. The theory of bank risk taking, and competition revisited. *Journal of Finance* 60: 1329–43. *Working Papers* 12: 1. doi:10.5089/9781475505054.001.
- (Boyd and Prescott 1986) Boyd, John H. and Edward Prescott. 1986. Financial intermediary-coalitions. *Journal of Economic Theory*, 38(2), 211-232. doi: [https://doi.org/10.1016/0022-0531\(86\)90115-8](https://doi.org/10.1016/0022-0531(86)90115-8).
- (Bureau Van Dijk and Fitch 2013) Bureau Van Dijk and Fitch. 2013. Available online: <https://www.bvdingo.com/es-es/> (accessed on 15 December 2017).
- (Calem and Rob 1999) Calem, Paul, and Rafael Rob. 1999. The impact of capital-based regulation on bank risk-taking. *Journal of Financial Intermediation* 8: 317–52. doi:10.1006/jfin.1999.0276.
- (Calomiris and Haber 2013) Calomiris, Charles and Haber Stephen (2013), *Fragile by Design: The Political Origins of Banking Crises and Scarce Credit*. Princetown University Press: Princeton, USA.
- (Calice and Zhou 2018) Calice, Pietro, and Nan Zhou. 2018. Benchmarking Costs of Financial Intermediation around the World. Available online: <http://blogs.worldbank.org/allaboutfinance/benchmarking-costs-financial-intermediation-around-world> (accessed on 25 January 2020).

- (Caprio and Klingebiel 1997) Caprio, Gerard, and Daniella Klingebiel. 1997. Bank Insolvency: Bad Luck, Bad Policy or Bad Banking? Washington, DC: The World Bank.
- (Carlson and Mitchener 2006) Carlson, Mark, and Kris James Mitchener. 2006. Branch banking, bank competition, and financial stability. *Journal of Money, Credit and Banking* 38: 1293–328.
- (Chiaramonte et al. 2015) Chiaramonte, Laura, Ettore Croci, and Federica Poli. 2015. Should we trust the Z-score? Evidence from the European banking industry. *Global Finance Journal* 28: 111–31.
- (Chinn and Dooley 1997) Chinn, Menzie D., and Michael P. Dooley. 1997. Financial repression and capital mobility: Why capital flows and covered interest rate differentials fail to measure capital market integration. *Monetary and Economic Studies* 15: 81–103.
- (Chortareas et al. 2011) Chortareas, Georgios E., Claudia Girardone, and Alexia Ventouri. 2011. Financial frictions, bank efficiency and risk: Evidence from the eurozone. *Journal of Business Finance & Accounting* 38: 259–87. doi:10.1111/j.1468-5957.2010.02226.x.
- (Cihák and Schaeck 2007) Cihák, Martin, and Klaus Schaeck. 2007. How well do aggregate bank ratios identify banking problems? *IMF Working Papers* 7: 1. doi:10.5089/9781451868388.001.
- (D’Erasmus 2018) D’Erasmus, Pablo 2018. Are higher capital requirements worth it? Curbs on bank leverage are intended to prevent bailouts but can slow economic growth. The challenge is to obtain precise estimates of the impact so policymakers can weigh the trade-off. *Economic Insights (Federal Reserve Bank of Philadelphia)* 3: 1.
- (Davis et al. 2011) Davis, E. Philip, Dilruba Karim, and Iana Liadze. 2011. Should multivariate early warning systems for banking crises pool across regions? *Review of World Economics* 147: 693–716.
- (Delis and Staikouras 2011) Delis, Manthos, and Panagiotis K. Staikouras. 2011. Supervisory effectiveness and bank risk. *Review of Finance* 15: 511–43. doi:10.1093/rof/rfq035.
- (Demirgüç-Kunt and Detragiache 1998) Demirgüç-Kunt, A., and E. Detragiache. 1998. The Determinants of Banking Crises in Developing and Developed Countries. *International Monetary Fund (IMF) Staff Papers*, vol. 45, 81–109.
- (Demsetz and Strahan 1997) Demsetz, Rebecca S., and Philip E. Strahan. 1997. Diversification, size, and risk at bank holding companies. *Journal of Money, Credit and Banking* 29: 300–13.
- (Duca and Peltonen 2013) Duca, Marco L., and Toumas A. Peltonen. 2013. Assessing systemic risks and predicting systemic events. *Journal of Banking and Finance* 37: 2183–95.
- (ECB 2016) ECB. 2016. Financial Stability Review. European Central Bank (ECB) <https://www.ecb.europa.eu/pub/pdf/fsr/financialstabilityreview201605.en.pdf>.

- (Eichengreen and Rose 1998) Eichengreen, Barry, and Andrew Rose. 1998. Staying afloat when the wind shifts: External factors and emerging-market banking crises. National Bureau of Economic Research, w6370.
- (Elsinger et al. 2006) Elsinger, Helmut, Alfred Lehar, and Martin Summer. 2006. Risk assessment for banking systems. *Management Science* 52: 1301–14. doi:10.1287/mnsc.1060.0531.
- (Enoch et al. 2016) Enoch, Charles, Bossu Wouter, Carlos Caceres, and Diva Singh. 2016. Financial Integration in Latin America. IMF: Washington, D.C, USA.
- (Federico and Vázquez 2012) Federico, P., and F. F. Vázquez. 2012. Bank funding structures and risk: Evidence from the global financial crisis. *IMF Working Papers* 12: 1. doi:10.5089/9781463933142.001.
- (Foos et al. 2010) Foos, Daniel, Lars Norden, and Martin Weber. 2010. Loan growth and riskiness of banks. *Journal of Banking and Finance* 34: 2929–40. doi:10.1016/j.jbankfin.2010.06.007.
- (Francis, 2014) Francis, William. 2014. UK deposit-taker responses to the financial crisis: What are the lessons? Available online: [https://www.openaire.eu/search/publication?articleId=od\\_\\_\\_\\_\\_645::09830744c0311d77f1fdf4e3de953511](https://www.openaire.eu/search/publication?articleId=od_____645::09830744c0311d77f1fdf4e3de953511) (accessed on 2 September 2020).
- (Galindo et al. 2010). Galindo, Arturo, Alejandro Izquierdo, and Liliana Rojas-Suarez. 2010. Financial integration and foreign banks in latin america: How do they impact the transmission of external financial shocks? ( No. IDB-WP-116). Washington, DC: Inter-American Development Bank (IDB). Available online: <https://www.econstor.eu/handle/10419/89137> (accessed on 2 September 2020).
- (García-Herrero 1997) García-Herrero, Alicia. 1997. Monetary Impact of a Banking Crisis and the Conduct of Monetary Policy. *IMF Working Papers*. 97. 10.2139/ssrn.86248.
- (García-Herrero et al. 2009) García-Herrero, Alicia, Sergio Gavilá, and Daniel Santabárbara. 2009. What explains the low profitability of Chinese banks? *Journal of Banking and Finance* 33: 2080–92. doi:10.1016/j.jbankfin.2009.05.005
- (Gavin and Hausmann, 1998) Gavin Michael, Hausmann Ricardo (1998) Macroeconomic Volatility and Economic Development. In: Borner S., Paldam M. (eds) *The Political Dimension of Economic Growth*. International Economic Association Series. Palgrave Macmillan, London. Available online: [https://doi.org/10.1007/978-1-349-26284-7\\_5](https://doi.org/10.1007/978-1-349-26284-7_5) (accessed on 2 September 2020).
- (Gelos, 2015). Gelos, Gaston. 2015. Financial soundness indicators. Washington, DC: International Monetary Fund. Available online: <http://portal.igpublish.com/iglibrary/search/IMFB0000071.html> (accessed on 2 September 2020).
- (Greuning and Bratanovic 2009) Van Greuning, Hennie & Bratanovic Sonja. 2009. Analyzing banking risk (3rd edition) The World Bank. doi:10.1596/978-0-8213-7728-4. Available online: <https://doi.org/10.1596/978-0-8213-7728-4> (accessed on 2 September 2020).

- (Georgieva 2020) Georgieva, Kristalina. 2020. A Joint Response for Latin America and the Caribbean to Counter the COVID-19 Crisis. Available online: <https://www.imf.org/en/News/Articles/2020/06/24/sp062420-a-joint-response-for-latin-america-and-the-caribbean-to-counter-the-covid-19-crisis> (accessed on 22 August 2020).
- (Gertler et al. (2012) Gertler, Mark, Nobuhiro Kiyotaki, and Albert Queralto. 2012. Financial crises, bank risk exposure and government financial policy. *Journal of Monetary Economics*, 59, S17-S34. doi:<https://doi.org/10.1016/j.jmoneco.2012.11.007>.
- (Goldstein et al. 2000) Goldstein, Morris, Carmen M. Reinhart, and Graciela L. Kaminsky. 2000. Assessing Financial Vulnerability, an Early Warning System for Emerging Markets: Introduction. Available online: <http://econpapers.repec.org/paper/pramprapa/13629.htm> (accessed on 27 December 2017).
- (Greuning 2009) Greuning, Hennie. 2009. Analyzing Banking Risk. Available online: <http://www.econis.eu/PPNSET?PPN=834954060> (accessed on 12 May 2019).
- (Hancock and Wilcox 1994) Hancock, Diana, and James A. Wilcox. 1994. Bank capital and the credit crunch: The roles of risk-weighted and unweighted capital regulations. *Real Estate Economics* 22: 59–94. doi:10.1111/1540-6229.00626.
- (Hughes and Mester 1998) Hughes, Joseph, and Loretta Mester. 1998. Bank capitalization and cost: Evidence of scale economies in risk management and signalling. *The Review of Economics and Statistics*, 80(2), 314-325. doi:10.1162/003465398557401.
- (IMF 2015) IMF 2015. World Economic Outlook. Uneven Growth. Short and Long-Term Factors. International Monetary Fund (IMF). World Economic and Financial Surveys. Available online: <https://www.imf.org/external/pubs/ft/weo/2015/01/> (accessed on 22 August 2020).
- (Jensen and Meckling 1976) Jensen, Michael C., and William H. Meckling. 1976. Theory of the firm: Managerial behaviour, agency costs and ownership structure. *Journal of Financial Economics* 3: 305–60. doi:10.1016/0304-405x(76)90026-x.
- (Kaminsky and Reinhart 1999) Kaminsky, Graciela L., and Carmen M. Reinhart. 1999. The twin crises: The causes of banking and balance-of-payments problems. *The American Economic Review* 89: 473–500. doi:10.1257/aer.89.3.473.
- (Kane 2016) Kane, Edward 2016. A theory of how and why Central-bank culture supports predatory risk taking at megabanks. *International Atlantic Economic Society* 44: 51–71. doi:10.1007/s11293-016-9482-x.
- Kauko, K. (2012) Kauko, Karlo. 2012. External deficits and non-performing loans in the recent financial crisis. *Economic Letters*, 115, 2.
- (Kleinov et al. 2014). Kleinov, Jacob, Tobias Nell, Silvia Rogler, and Andreas Horsch. 2014. The Value of Being Systemically Important: Event Study on Regulatory Announcement for Banks. *Applied Financial Economics*, 24(24), 1585-1604.
- (Köhler 2012) Köhler, Matthias. 2012. Which Banks are More Risky? The Impact of Loan Growth and Business Model on Bank Risk-Taking. Frankfurt: Deutsche Bundesbank.

- (Laeven and Levine 2009) Laeven, Luc, and Ross Levine. 2009. Bank governance, regulation and risk taking. *Journal of Financial Economics* 93: 259–75. doi:10.1016/j.jfineco.2008.09.003.
- (Laeven and Valencia 2012) Laeven, Luc, and Fabián Valencia. 2012. Systemic banking crises database: An update. *IMF Working Papers* 12: 1. doi:10.5089/9781475505054.001.
- (Laeven et al 2016) Laeven, Luc & Ratnovski, Lev & Tong, Hui 2016. Bank size, capital, and systemic risk: Some international evidence. *Journal of Banking & Finance*, 69, S25-S34.
- (Lamas and Mencía 2019). Lamas, Matías and Javier Mencía. 2019 What drives sovereign debt portfolios of banks in a crisis context? Frankfurt am Main, Germany: European Systemic Risk Board. doi:10.2849/619802
- (Lang and Schmidt 2016) Lang, Michael, and Paul G. Schmidt. 2016. The early warnings of banking crises: Interaction of broad liquidity and demand deposits. *Journal of International Money and Finance* 61: 1–29. doi:10.1016/j.jimonfin.2015.11.003.
- (Lang et al. 2018) Lang, Jan, Toumas Peltonen, and Peter Sarlin. 2018. A Framework for Early Warning Modelling with an Application to Banks. European Central Bank (ECB) Working paper series, 2182.
- (Lang and Forletta 2019) Lang, Jan and Marco Forletta. 2019 Bank capital-at-risk: measuring the impact of cyclical systemic risk on future bank losses. *ECB Working Paper Series*, forthcoming.
- (Lee and Hsieh 2013) Lee, C., and M. Hsieh. 2013. The impact of bank capital on profitability and risk in Asian banking. *Journal of International Money and Finance* 32: 251–81. doi:10.1016/j.jimonfin.2012.04.013.
- (Liu et al. 2013) Liu, Hong, Philip Molyneux, and John Wilson. 2013. Competition, and stability in European banking: A regional analysis. *The Manchester School* 81: 176–201. doi:10.1111/j.1467-9957.2011.02285.x.
- (López 1999) López, Jose A. 1999. Using CAMELS Ratings to Monitor Bank Conditions. Federal Reserve Bank of San Francisco, June 11. Available online: [www.frbsf.org/economic-research/publications/economic-letter/1999/june/using-camels-ratings-to-monitor-bank-conditions/](http://www.frbsf.org/economic-research/publications/economic-letter/1999/june/using-camels-ratings-to-monitor-bank-conditions/) (accessed on 7 March 2019).
- (Lund-Jensen 2012) Lund-Jensen, Kasper. 2012. Monitoring Systemic Risk Based on Dynamic Thresholds. Available online: <http://www.econis.eu/PPNSET?PPN=726101990> (accessed on 12 March 2018).
- (Macchiarelli 2018) Macchiarelli, Corrado 2018. Post-Crisis Excess Liquidity and Bank Lending. Brussels: European Parliament.
- (MacDonald et al. 2015) MacDonald, Ronald, Vasilios Sogiakas, and Andreas Tsopanakis. 2015. An investigation of systemic stress and interdependencies within the Eurozone and Euro Area countries. *Economic Modelling* 48: 52–69.
- (Mäkinen and Solanko 2017) Mäkinen, Mikko, and Laura Solanko. 2017. Determinants of Bank Closures: Do Changes of CAMEL Variables Matter? Available online:

<https://helda.helsinki.fi/bof/handle/123456789/14948> (accessed on 21 December 2018).

- (Maurin and Toivanen, 2012) Maurin, Laurent and Mervi Toivanen. 2012. Risk, capital buffer and bank lending: a granular approach to the adjustment of euro area banks, No 1499, Working Paper Series, European Central Bank.
- (Martynova 2015) Martynova, Natalya 2015. Bank Profitability and Risk-Taking. (No. 15). Washington, DC: International Monetary Fund. doi:10.5089/9781513517582.001.
- (Maudos 2017) Maudos, Joaquin 2017. Income structure, profitability, and risk in the European banking sector: The impact of the crisis. *Research in International Business and Finance* 39: 85–101. doi:10.1016/j.ribaf.2016.07.034.
- (Maudos and de Guevara 2004) Maudos, Joaquin, and Juan Fernández de Guevara. 2004. Factors explaining the interest margin in the banking sectors of the european union. *Journal of Banking & Finance* 28: 2259–81.
- (Nguyen et al. 2019) Nguyen, Quang T. T., Son T. B. Nguyen, and Quang V. Nguyen. 2019. Can higher capital discipline bank risk: Evidence from a meta-analysis. *Journal of Risk and Financial Management* 12: 134. doi:10.3390/jrfm12030134.
- (Nicolo et al. 2003) De Nicolo, Gianni, Patrick Honohan and Alain Ize. 2003. Dollarization of the Banking System, Good or Bad. IMF: Washington D.C.: International Monetary Fund.
- (Nyman et al. 2018) Nyman, Rickard, Sujit Kapadia, David Tuckett, David Gregory, Paul Ormerod, and Robert Smith. 2018. News and Narratives in Financial Systems: Exploring Big Data for Systemic Risk. Bank of England Staff Working Paper No. 704: London, Bank of England.
- (Obstfeld, 2012) Obstfeld, Maurice. 2012. Does the Current Account Still Matter? *American Economic Review*, 102 (3): 1–23.
- (Oet and Ong 2011) Oet, Mikhail V., and Stephen J. Ong. 2011. SAFE: An Early Warning System for Systemic Banking Risk. Available online: [https://www.openaire.eu/search/publication?articleId=od\\_\\_\\_\\_\\_645::6472a15e536bfe669833cc6921b624e9](https://www.openaire.eu/search/publication?articleId=od_____645::6472a15e536bfe669833cc6921b624e9) (accessed on 03 March 2019).
- (Pellegrini et al. 2019) Pellegrini, Carlo, Laura Pellegrini, and Emiliano Sironi. 2019 Explaining Systemic Risk in Latin American Banking Industry over 2002–2015, *Asia-Pacific Contemporary Finance and Development (International Symposia in Economic Theory and Econometrics, Vol. 26)*, Emerald Publishing Limited, pp. 287–309.
- (Petria et al. 2015) Petria, Nicolae, Bodgan Capraru, and Iulian Ihnatov. 2015. Determinants of banks' profitability: Evidence from EU 27 banking systems. *Procedia Economics and Finance* 20: 518–24. doi:10.1016/s2212-5671(15)00104-5.
- (Petropoulos et al. 2017) Petropoulos, Anastasios, Vasilis Siakoulis, Evangelos Stavroulakis, and Nikolaos E. Vlachogiannakis. Predicting Bank Insolvencies Using Machine Learning Techniques. EBA, European Banking Authority April. Available online: [eba.europa.eu/documents/10180/1813140/Session+2+](http://eba.europa.eu/documents/10180/1813140/Session+2+)

+Predicting+bank+insolvencies+using+machine+learning+techniques.pdf  
(accessed on 2 September 2020).

- (Ravi and Ravi 2007) Ravi, Kumar P., and Vadlamani Ravi. 2007. Bankruptcy prediction in banks and firms via statistical and intelligent techniques—A review. *European Journal of Operational Research* 180: 1–28. doi:10.1016/j.ejor.2006.08.043.
- (Reinhart and Rogoff 2013) Reinhart, Carmen M., and Kenneth S. Rogoff. 2013. Banking crises. *Journal of Banking & Finance* 37: 4557–73.
- (Roengpitya et al. 2014) Roengpitya, Rungporn, Nikola Tarashev, and Kostas Tsatsaronis. 2014. Bank business models. *BIS Quarterly Review* 2014: 55–65.
- (Rojas-Suarez 2001) Rojas-Suarez, Liliana. 2001. Rating Banks in Emerging Markets: What Credit Rating Agencies Should Learn from Financial Indicators. Institute for International Economics (IIE) Washington D.C., USA.
- (Rojas-Suárez and Weisbrod 1996) Rojas-Suárez, Liliana, and Steven R. Weisbrod. 1996. Banking Crises in Latinamerica: Experience and Issues. (No. 321). Washington, DC: Inter-American Development Bank (IDB).
- (Rono and Traore 2018) Rono, Jonathan and Assetou Traore. 2018. Banks and sovereign risk. A granular view. Seminar for Senior Bank Supervisors from Emerging Economies, Washington, D.C. October 25 2018.
- (Schich and Byoung-Hwan 2010) Schich, Sebastian, and Kim Byoung-Hwan. 2010. Systemic Financial Crises: How to fund Resolution. *OCDE Journal: Financial Market Trends* 2010: 1–34.
- (Schliephake 2016) Schliephake, Eva 2016. Capital regulation and competition as a moderator for banking stability. *Journal of Money, Credit and Banking*, 48(8), 1787-1814. Doi:10.1111/jmcb.12371
- (Sheng 1996) Sheng, Andrew 1996. Bank Restructuring Lessons from the 1980s. Washington, DC: The World Bank, p. 15384. Available online: <http://documents1.worldbank.org/curated/en/533291468766518413/pdf/multi-page.pdf> (accessed on 14 March 2018).
- (Sherbo and Smith 2013) Sherbo, Andrew J., and Andrew J. Smith. 2013. The Altman Z-score bankruptcy model at age 45: Standing the test of time? *American Bankruptcy Institute Journal* 32: 40.
- (Singh 2005) Singh et al. 2005. Latin American Financial Systems: Crises and Reforms. International Monetary Fund (IMF) Working Papers. Washintong D.C., USA.
- (Stackhouse 2018) Stackhouse, Julie. 2018. “CAMELS Ratings: Liquidity.” St. Louis Fed, Federal Reserve Bank of St. Louis, 19 Dec. 2018. Available online: [www.stlouisfed.org/on-the-economy/2018/december/camels-ratings-liquidity](http://www.stlouisfed.org/on-the-economy/2018/december/camels-ratings-liquidity) (accessed on 12 March 2019).
- (Stiroh and Rumble 2006) Stiroh, K. J., and A. Rumble. 2006. The dark side of diversification. *Journal of Banking & Finance* 30: 2131–61.

- (TengTeng et al. 2019) TengTeng, Xu, Kun Hu, and Udaibir Das. 2019. Bank Profitability and Financial Stability IMF 2019. Available online: <https://www.imf.org/~media/Files/Publications/WP/2019/wp1905.ashx> (accessed on 1 March 2020).
- (Uhde and Heimeshoff 2009) Uhde, Andre, and Ulrich Heimeshoff. 2009. Consolidation in banking and financial stability in Europe. *Journal of Banking & Finance* 33: 1299–311.
- (Valencia and Laeven 2008) Valencia, Fabian, and Luc Laeven. 2008. Systemic banking crises: A new database. *IMF Working Papers* 8: 1. doi:10.5089/9781451870824.001
- (Windmeijer 2005) Windmeijer, F. 2005. A finite sample correction for the variance of linear efficient two-step GMM estimators. *Journal of Econometrics* 126: 25–51.
- (Yi 2012) Yi, W. 2012. Z-score model on financial crisis early-warning of listed real estate companies in china: A financial engineering perspective. *Systems Engineering Procedia* 3: 153–7. doi:10.1016/j.sepro.2011.11.021.



# 3

## Essay 2

# **Understanding The Investment Decisions Of Small Banks In Sovereign Debt Portfolios**

## Synopsis

The idea for the second paper was evident during my stay in the European Central Bank. There I worked in the Risk Analysis and Methodological Support Division which, jointly with national competent authorities (NCAs), supervises the Less Significant Institutions<sup>15</sup> (LSI). This opportunity allowed me to familiarize with different particularities of the LSI sector. One remarkable difference was that these institutions have, was their behaviors with regards sovereign risk. In a context where big European banks increased the total holdings of sovereign bonds LSI seem to have reduced it. Bast majority of the research in this field had focused on the understanding why big banks increase their sovereign debt exposure. Thus, the catalyst for this research was to understand the behavior of small European banks towards the sovereign debt exposure.

This topic has particularly relevance for banks located in countries under stress. These banks behavior have made the policy markets and academic to wonder if the motivation behind the increase in sovereign debt was consequence of “moral suasion”. As described priorly, the moral suasion is the “stress” that governments under fiscal stress exercise to local banks to make them increase the purchase amounts of sovereign bonds to sustain de demand.

This paper, in line with the first one, continuing looking at the banking risk factors. Additionally, this paper also raises attention to a more regulatory complexity. Firstly, this paper starts introducing a concept of regulation imperfection. This addresses the issue that while the BIS has recommended reviewing the classification this exposure has from a credit risk point of view, in practicality this has not been addressed. This leaves a space for future imperfections. Secondly the paper looks at the risk assumption of small banks to understand how moral suasion can affect them and why they have a behavior different to big banks regarding purchase sovereign bonds.

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<sup>15</sup> Are banks that do not fulfil any of the significance criteria specified in the SSM Regulation – in contrast to significant institutions (SIs) that do fulfil at least one of them.

# UNDERSTANDING THE INVESTMENT DECISIONS OF SMALL BANKS IN SOVEREIGN DEBT PORTFOLIOS<sup>\*</sup>

Mariña Martínez Malvar<sup>16</sup>, Laura Baselga Pascual<sup>17</sup>

## ABSTRACT

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This paper studies the determinants of the sovereign debt portfolios of small European banks. We cover the time frame from 2010 to 2017, including the peak of the European debt crisis. Our analysis focuses on Less Significant Institutions (LSI), a group of small financial institutions that show a different sovereign risk exposure from larger institutions. Our results indicate that LSIs with strong credit quality and low capitalization tend to increase their investment in sovereign debt. We apply a GMM-system estimator to address endogeneity and unobserved heterogeneity. Overall, our results contribute to a better understanding of the risk determinants of LSIs, enriching the debate on supervision and regulation proportionality, as small European banks present distinctive behavior. According to our results, a debate on macroprudential regulations to reconsider a country's sovereign debt as risk free is desirable to reduce the risk exposure of LSIs.

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*JEL classification:* G01, G21, G23

*Keywords:* Financial crisis, financial institutions, sovereign debt exposure; less significant institutions, credit risk

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## 1. Introduction

Sovereign debt crises usually take place before or after banking crises. The relationship between sovereign debt exposure and bank risk<sup>18</sup> is commonly called the “sovereign-bank nexus”, “deadly embrace”, “vicious circle” or “diabolic loop” (e.g., Farhi and Tirole; 2015, Brunnermeier et al. 2016; Farhi et Tirole, 2018).

This paper contributes to the literature by empirically examining the bank-specific and macroeconomic factors that motivate European Less Significant Institutions<sup>19</sup> (LSIs) to increase their sovereign debt exposure. As defined by the European Central Bank (ECB, 2020), by LSI, we refer to banks that do not fulfil any of the significance criteria specified in the SSM Regulation (i.e.: size, the importance to the economy of its home country or the EU, and the significance of its cross-border activities). In practice, the bulk of LSIs are smaller banks whose assets do not exceed €30 billion.

To the best of our knowledge, the literature analyzing factors of sovereign debt exposure is mostly focused on large banks (Gennaioli et al, 2018; Lamas and Mencía 2019). However, LSIs represent almost one-fifth of the total assets of the banking sector of the euro area (European Central Bank, 2018). Sovereign exposure represents a significant part of LSI balance sheets (approximately €500 billion in total), more than 10% of LSI assets, while levels vary by country. For LSIs, more than 80% of such exposures are to domestic counterparties (in contrast to 50% for SIs) (ECB, 2018). As shown in Figure 1, there are different trends between LSIs and Significant Institutions (SIs) in their securities exposure. As we can observe in Figure one the evolution across the time of the total exposure to sovereign risk of SI and LSI does not seem to follow the same path. While in the period from 2013 to 2014 the SI

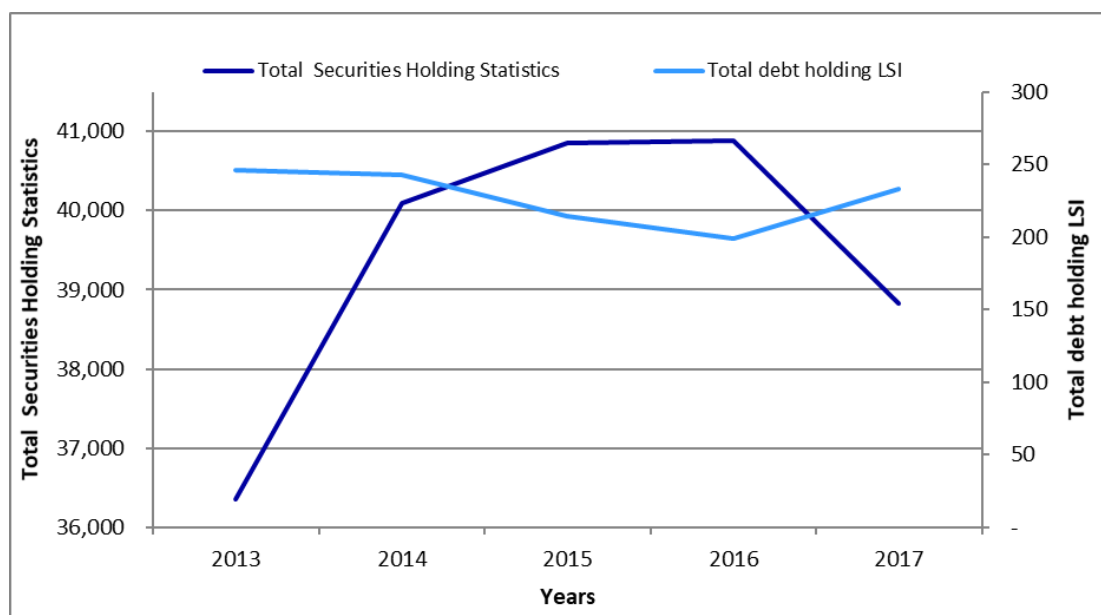
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<sup>18</sup> Poor sovereign debt performance can easily be reflected in the bank’s balance sheets because it can decrease the value of the bank’s sovereign bonds in the bank’s assets. It also involves the deterioration of the bank’s collateral, which will lead to higher funding costs. In this scenario of banks’ deterioration, it is possible that rating agencies downgrade the sovereign debt as the risk of bank bailout increases. Definitively, a rating downgrade will affect banks’ balance sheets, which will start the process over again.

<sup>19</sup> Article 6 (4) of the SSM Regulation and Article 39 of the SSM Framework Regulation establish the criteria and rules for classifying a credit institution as significant or less significant. This classification determines whether a credit institution is supervised directly by the ECB or the NCA.

security holdings dramatically raise, the LSI decrease the total holdings exposure. Also, this behavior seems to have been opposite in the period from 2014 to 2016 as LSIs have increased their sovereign debt exposure since 2016, while SIs have consistently reduced their exposure. Consequently, it is of interest to perform further analysis of the factors that have recently motivated the holding of sovereign debt and to understand how the LSI decision to invest in sovereign debt differs from the SI.

Figure 1: Evolution of total securities holding statistics of banks across Europe



NOTES: This figure describes the evolution of Securities Holding Statistics which are collected on a security by security basis.  
Source European Central Bank Statistical Data Warehouse

During the global financial crisis (2007-2008), the link between sovereign debt exposure and risk in the European financial system led to the European sovereign debt crisis (Becker and Ivashina 2017; Ongena et al, 2019). Following the global financial crisis in 2008, Eurozone countries experienced an increase in public debt issuance, which was largely absorbed by the domestic financial sector (Becker and Ivashina, 2017). In fact, during the 2007-2012 period, the amount of government debt held by the European financial domestic system increased from 26 to 39% of the euro area gross domestic product (GDP). During the purchase process, home-country bias<sup>20</sup> occurred. This home-country bias can be

<sup>20</sup> Investors tend to hold a disproportionate share of domestic assets in their portfolio (Oehler et al. 2007) <sup>3</sup> The Single Supervisory Mechanism (SSM) is the system of banking supervision in Europe, which is formed, by the ECB and the national supervisory authorities of the participating countries.

understood by the expectation that a potential bailout mechanism will take place at the country level, favoring institutions with greater exposure to domestic sovereign debt (Becker and Ivashina, 2017; European Commission, 2007; Navaretti et al., 2016).

Additionally, during the global financial crisis, the harmful effects of sovereign risk on financial strength emerged (Erce, 2015, BIS; 2017). The increase in sovereign yields and the increase in debt levels had strong implications for the financial system via an increase in funding costs and a tightening of the credit supply (Correa and Sapriza, 2014; Neri, 2013). Additionally, banks suffered losses because of credit default swap (CDS) spreads on bonds issued by banks. In the case of Italy, banks suffered losses from 29 to 73 billion euros (Neri, 2013). Moreover, due to losses in domestic bond exposures, some European banks faced stress on their capital and liquidity (Correa and Sapriza, 2014). Black et al. (2015) show that sovereign default risk was one of the main causes of the increase in systemic risk in European banks in 2011. Sovereign exposure can serve to transfer a sovereign crisis into the banking system, as poor sovereign debt performance can deteriorate a bank's balance sheet, its collateral, and its funding conditions (Noyer 2010). When sovereign debt defaults and assets need to be written off or rescheduled, banks are the first institutions to be damaged (Ari, 2016).

Sovereign bonds are not entirely risk-free assets (BIS, 2017). Nevertheless, economic agents tend to disregard their credit risk, perceiving domestic sovereign securities as safe assets. In fact, banks have an incentive to arbitrage regulatory rules, as sovereign debt securities have a zero risk-weighting factor (Acharya and Steffen, 2014). In general, sovereign debt is less expensive than other assets due to regulatory risk considerations (Lenarcic et al., 2016). Thus, banks tend to increase their risk profile by, for example, investing in sovereign debt in periods of sovereign stress to raise their returns (Acharya and Steffen; 2013). One of the goals of the Single Supervisory Mechanism (SSM)<sup>3</sup> was to limit the

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<https://www.bankingsupervision.europa.eu/about/thessm/html/index.en.html>

negative consequences of the interconnectedness between banks and sovereign debt, the so-called “vicious circle”.

Our results show a negative correlation between capitalization and the share of sovereign debt of LSIs, suggesting moral hazard behavior, as poorly capitalized banks could use their sovereign exposure to generate profits and improve capital ratios (Acharya and Steffen, 2015). This behavior resembles that of larger banks. It is relevant to question if these banks, despite being more risk aware than larger banks (Gambacorta and Mistrulli, 2003), with limited access to wholesale financing (Budnik, et al, 2019) need an alternative for increase capitalization in moments of distress. The relevance of the wellbeing of these small institutions can be justify by the important role that they have for financing SME across Europe. Nevertheless, unexpectedly, we show a positive correlation between credit quality and sovereign exposure, suggesting that LSIs with better credit quality tend to increase their sovereign debt exposure.

Our results are of interest for supervisors to further develop macroprudential regulations. Our work provides support to Lanotte et al. (2016), suggesting eliminating the current treatment of sovereign debt as risk free.

The paper is structured as follows: in section 2, we provide a summary of the related works and our research hypotheses; section 3 describes the sample and variables used; and in section 4, we provide the empirical analyses. Finally, section 5 provides a summary and the main conclusion of the paper.

## **2. Related literature and research hypotheses**

Holding excessive sovereign debt in their balance sheets can increase bank risk. The so-called “sovereign-bank nexus” can amplify economic shocks in periods of stress (Dell’Ariccia et al; 2018). However, banks have an important role in providing financing to governments and in stabilizing

sovereign markets during critical moments (Battistini et al, 2013; Asonuma et al, 2015; Acharya and Steffenm 2015; Becker and Ivashina 2017; Ongena et al, 2019; Lamas and Mencía 2019).

The main negative impact of sovereign debt exposure is the asset deterioration suffered by banks because of the decrease in the collateral value of sovereign securities (BIS, 2011 and 2018). This loss of asset value can produce higher funding costs and liquidity concerns for the financial system. Zoli (2013) shows how Italian sovereign risk premiums impacted the funding costs and lending conditions of domestic banks.

The impact of sovereign debt exposure on the risk of the financial system has been addressed in the literature; for instance, a persistently high sovereign risk premium can lead to higher rates on customer deposits (Grigorian and Manole, 2016). Indeed, banks without existing exposure to sovereign debt might be tempted to invest in domestic sovereign debt to reduce the probability of sovereign debt default. By preventing the deterioration of sovereign debt, they aim to reduce the effect on bank risk, known as the “self-preservation hypothesis” (Lamas and Mencia, 2019; ESRB, 2015).

In 2015, the Basel Committee reviewed the current regulatory treatment of sovereign debt. However, previous regulations prevailed, and a 0% risk weight for each country’s own sovereign debt was applied. Even considering the low probability of default across OECD countries (Reinhart and Rogoff, 2008), the risk of sovereign debt exposure cannot be underestimated. Furthermore, there is political pressure to increase the sovereign debt exposure of banks (Lenarcic et al, 2016; Ongena, et al, 2016; Altavilla et al, 2017; Marco and Macchiavelli, 2016). High-risk sovereign issuers can apply “moral suasion” to banks in their jurisdiction to increase domestic sovereign holdings. By doing this, governments ensure their financing.

Due to the potential hazard of banks, it is important to understand the incentives of financial institutions to increase their sovereign debt exposure. In the following subsections, we present the main variables that affect the sovereign debt share of banks according to the scientific literature. We try to classify the different factors that seems to be driving the sovereign exposure across the literature. For this purpose, we used the CAMEL system to organize the variables explaining sovereign risk, in a methodological and comprehensibly way that allow us to analyze the risk in a uniform manner. The CAMEL<sup>21</sup> (Capital, Asset Quality, Management, Earnings and Liquidity) approach allow us to select the bank-specific determinants of sovereign debt exposure.

### **2.1. Capitalization**

Previous literature finds a significant relationship between bank capitalization and sovereign debt exposure (Acharya and Steffen, 2014; Battistini et al. 2013; Zoli, 2013; Lamas and Mencia, 2019; Affinito et al., 2016; and Buch et al., 2016). Acharya and Steffen (2014) analyse the sovereign debt crisis in the euro area and show that undercapitalized banks may take a “gamble for resurrection” strategy. This “gamble” is made via carry trades, such as buying high-yield government bonds with little capital requirements, which allows banks to use the cheap liquidity provided by the Euro system. In a similar way, Ari (2018) states how undercapitalized banks increased their exposure to sovereign debt during the most recent crises of 2008 and 2012. Moreover, some banks can engage in moral hazard strategies. Lamas and Mencia (2019) find that most banks with a stronger propensity to accumulate high-yield sovereign bonds are distressed institutions. Buch et al. (2016) focus on sovereign bond portfolios of German banks, concluding that there is a proportion of banks that are not always active in sovereign bond markets. They detect that banks that do not hold sovereign bonds tend to be smaller, better capitalized and more engaged in interbank lending. Regarding banks with exposure, Buch et al. (2016)

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<sup>21</sup> This system was introduced in the 1980s by US supervisors for the on-site examination of banking institutions enables supervisors to compare banks with their peers over time (Stackhouse 2018). The CAMEL rating is extensively used in the literature (e.g.: Chiamonte et al. 2015; Stiroh and Rumble 2006; Mäkinen and Solanko 2017). The CAMEL classification is also applied by several international banking supervisors in their Early Warning Systems (e.g.: Lang et al. 2018; Nyman et al. 2018).

conclude that larger, lower capitalized banks with a lower share of customer loans have a greater propensity to hold government debt.

As most literature negatively links bank capitalization and sovereign debt exposure, our first hypothesis states the following:

**Hypothesis 1:** *“There is a negative relationship between bank capitalization and sovereign debt exposure.”*

## **2.2. Credit quality**

When banks are not able to optimally allocate their resources through credit, they can use sovereign bonds to improve the quality of their credit portfolios (Bolton and Jeanne, 2011 and Lamas and Mencía, 2019). Sovereign bonds offer an alternative funding source with lower capital requirements for banks that have incurred a bad credit risk allocation. These banks with high nonperforming loan<sup>22</sup> (NPL) levels experience limited lending, as they might not be able to target adequate borrowers in the traditional market, and sovereign bonds seem to be a profitable option (Lamas and Mencía; 2019).

In the same way, when sovereign debt is under distress, banks also tend to adjust their lending behavior (Bolton and Jeanne, 2011). Banks aim to buy sovereign bonds to reduce the probability of a sovereign default and its consequences for the financial system (ESRB, 2015). Banks incur this purchase despite the short-term negative effects. For example, an increase in direct holdings of sovereign debt can weaken the bank’s balance sheet, increasing its risk. The extent of this effect depends on whether the securities are carried at market value or amortized cost. When bonds are held as available-for-sale, they are assessed at a fair value. Hence, large price fluctuations affect bonds’ valuation, the volatility of banks’ profits and even banks’ funding conditions. Conversely, sovereign bonds that are held-to-

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<sup>22</sup> More information about NPL levels can be found in the guidance to banks on non-performing loans.

maturity are evaluated at amortized costs (Buch et al., 2016; BIS, 2011). Thus, we hypothesize the following:

**Hypothesis 2:** *“There is a negative relationship between the credit quality of a bank and its sovereign debt exposure.”*

### **2.3. Liquidity**

Several authors study the relationship between bank liquidity and sovereign debt exposure (Affinito et al., 2016, Ongena et al., 2016; Desislava et al., 2019; Grigorian and Manole, 2016 and Angeloni and Wolff, 2012).

By holding government liquid bonds, banks can maintain their liquidity levels. Sovereign securities can provide liquidity to banks while enabling them to satisfy demands from depositors (Gennaioli et al. 2013). For example, a bank with low liquidity can obtain credit from the central bank against sovereign debt securities (considered adequate collateral). Consequently, banks have an incentive to buy bonds and use them as collateral to obtain long-term funding at attractive conditions from the central bank. However, this also strengthens home bias, which could lead to an additional banking crisis in case of the deterioration of sovereign debt quality (Acharya and Steffen, 2014; Bolton and Jeanne 2011).

Another scenario in which sovereign debt can work as a tool to improve liquidity is a “drying-up” of liquidity, when banks have more difficulties rolling over their bonds while optimally allocating their resources (Gennaioli et al. 2013). Subsequently, banks can temporarily invest part of their liquidity in short-term government bonds to redeem mature bonds (Albertazzi et al, 2014; Broner et al., 2014). This temporary allocation allows banks to take advantage of central bank liquidity facilities (Lamas et Mencía, 2019).

During a sovereign crisis, in which there is uncertainty about the quality of bank assets, there can be funding pressure on banks. To limit the effects of bank liquidity shortages, central banks can provide funding facilities against a range of collateral. In this scenario, credit risk shifts to central banks, creating moral hazard conditions that can affect sovereign credit risk on bank funding conditions (BIS, 2013). Therefore, our third hypothesis states the following:

**Hypothesis 3:** “There is a positive relationship between the liquidity of a bank and its level of sovereign debt exposure.”

#### **2.4. Profitability**

Banks can engage in moral hazard behavior by shifting their portfolios towards sovereign debt to maximize their returns; although this process, they take advantage of the regulatory treatment of sovereign debt as a source of low-cost funding to increase profitability (Gennaioli et al. 2013; and Lamas and Mencía, 2019). This behavior can be pursued by banks that present limitations in allocating their resources through maturity transformation.

Additionally, banks have incentives to invest in sovereign bonds in periods in which there is a large supply of deposits or lower demand for loans (Ongena et al., 2016). During these periods, banks need to efficiently allocate their deposits to maintain their profitability. Sovereign bonds are an opportunistic alternative to allocate resources when a bank is not efficient or has limitations in generating demand for loans. Thus, we hypothesize the following:

**Hypothesis 4:** “There is a negative relationship between the profitability of a bank and its level of sovereign debt exposure.”

### 3. Sample and variables

#### 3.1 .Sample selection

LSIs are banks that do not fulfil the criteria (related to size, economic performance, cross-border activities, and financial public assistance) defined by the SSM regulations to be considered significant institutions. LSIs represent approximately 16% of all SSM banking assets. They are mainly concentrated in Germany, Austria, and Italy (ECB, 2018).

We obtain our data from the SNL database<sup>23</sup>, and due to data availability, we focus on the time span from 2010 to 2017, which includes the peak of the European sovereign debt crisis between 2010 and 2012. Our sample consists of almost 2,000 observations of 443 LSIs from 17 countries in the eurozone (Austria, Cyprus, Germany, Spain, Finland, France, Greece, Ireland, Italy, Lithuania, Luxembourg, Latvia, Malta, Netherlands, Portugal, Slovenia, and Slovakia). Due to the differences in accounting systems used, there are constraints on the data comparability. LSIs that report accounts using the national Generally Accepted Accounting Principles (GAAP) and that are not in line with the International Financial Reporting Standards ECB (2018) are excluded from the sample and consequently from the analysis due to the lack of comparability between the different accounting principles.

Those entities with abnormal ratios or extreme values are eliminated from the sample as outliers. We remove observations that are below the lower bound or above the upper bound. The formula for the lower bound is  $Q^1 - 1.5 * IQD$ .<sup>25</sup> The formula to calculate the upper bound is  $Q^3 + 1.5 * IQD$ .

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<sup>23</sup> SNL Financial Institutions and Bank Data are a global database for searching and analysing banks and insurance companies. This global database is provided by S&P Global Market Intelligence.

<sup>24</sup> Quartile.

<sup>25</sup> Interquartile Distance Q1-Q3.

Table 1. Distribution observations across country

Country	N of banks per country	Total number of observations per country
Austria	11	58
Cyprus	2	7
Germany	20	58
Spain	27	130
Finland	15	62
France	2	7
Greece	3	11
Ireland	2	5
Italy	314	1,710
Lithuania	3	7
Luxembourg	3	7
Latvia	5	8
Malta	4	15
Netherlands	14	58
Portugal	9	38
Slovenia	3	8
Slovakia	6	31
Total observations	443	2,220

Notes: Distribution of firms and observations per country

Table 2. Distribution observations across countries in total assets

Country	Total assets distribution per country %
AT	8.1%
CY	0.3%
DE	5.3%
ES	10.1%
FI	0.6%
FR	0.4%
GR	0.1%
IE	7.2%
IT	45.9%
LT	0.1%
LU	0.0%
LV	0.1%
MT	0.2%
NL	17.4%
PT	3.4%
SI	0.1%
SK	0.7%
Total	100%

Notes: Distribution of banks per country in terms of total assets.

Table 1 shows the number of banks and observations in the sample by country. As seen in the table, the distribution of LSIs across countries is quite irregular, with a higher concentration in Italy, as our analysis was made prior to the consolidation of the cooperative banking sector into three major groups<sup>26</sup>. However, Table 2 shows that the total weight of Italian banks is less significant in terms of total assets.

### **3.2. Variables**

We examine four bank-specific determinants of sovereign exposure that are common in the literature. In Table 3, we summarize the variable descriptions, the expected signs for our hypotheses and the main references.

#### Dependent variable

Our dependent variable is the ratio of total securities to total assets (*TSTA*). As defined in the SNL database, “total securities” include all securities in trading, available for sale or held to maturity excluding segregated securities or securities pledged as collateral for broker dealers and asset managers.

Even though “total securities” include more than government bonds, they are often used in the literature as a proxy for sovereign debt exposure, as sovereign securities represent a large percentage of total securities (Fратиanni et Marchionne, 2016; Merler and Pisani-Ferry, 2012; Buch et al., 2016). Another reason to choose this variable is based on to data availability and data quality issues.

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<sup>26</sup> The Italian credit cooperative banks (BCC) in the first half of 2019 joined the two-cooperative banking system (ICCREA and Cassa Centrale Banca) classified within the SI sector (ECB, 2018).

### Explanatory variables:

Following Bertay et al. (2017) and Demirgüç-Kunt et al. (2013), we measure capitalization by the total equity to total assets (TETA). We use the ratio of problem loans to total assets (PrLTA) to measure credit quality, like Lamas et Mencia (2019) and Affinito et al. (2016). Following Affinito et al. (2016), we use total loans to customers to total customer deposits (NCLtoD) as a measure of bank “illiquidity”. Finally, similar to Erce (2015), we use the return on average assets (ROAA) to address profitability.

### Bank-specific control variables:

Although the predominant business model across the LSI sector is retail banking, there is considerable heterogeneity between the different institutions (ECB, 2018). Therefore, we control for additional bank-specific characteristics that might affect sovereign debt exposure, such as the size of a bank or its business model.

We proxy bank size (*TA*) by the natural logarithm of total assets (Affinito et al. 2016). Looking at the business model, we consider the ratio of total deposits to total assets (*TDfCTA*) to measure the degree of retail banking activities, and the asset structure of the bank is proxied by the ratio of net loans to customers to total assets (*NTtCTA*) (Agresti et al, 2008). Last, the ratio of the net interest margin (*NiM*) allows us to control for the lending margins (ECB, 2020).

### Macroeconomic controls

The macroeconomic conditions in which financial institutions operate can affect their decision to invest in sovereign debt. Our sample consists of banks from the eurozone. Consequently, we contemplate country-level characteristics in three main categories: institutional framework, national wealth and economic outlook and external vulnerabilities (as mentioned before, policy flexibility is omitted because the sample is subject to the same regulations). The institutional framework is proxied

by Ares, CStr, OSP and PriM. The activity restriction index (Ares) includes restrictions on securities, insurance, and real estate activities plus restrictions on the banks owning and controlling nonfinancial firms. Capital stringency (CStr) captures whether the capital requirement reflects certain risk elements and deducts certain market value losses from capital before minimum capital adequacy is determined. Official supervisory power (OSP) is connected to whether supervisors have the authority to take specific actions to prevent and correct problems and circumstances that can help to prevent banks from engaging in excessive risk-taking behavior and thus improve bank development, performance, and stability. Finally, private monitoring (PriM) shows the degree to which banks are forced by supervisor authorities to disclose accurate information to the public and whether there are incentives to increase market discipline. These regulations, which promote and facilitate the private monitoring of banks, are associated with better banking sector outcomes.

In a second category, we look at a country's national wealth and economic outlook. Banks can engage in a carry trade strategy that allows them to profit from differences between high-return sovereign bonds and rates of short-term unsecured funding in the wholesale market (Acharya and Steffen, 2015). *Yield* works as an incentive to invest in sovereign debt for undercapitalized banks, as they would benefit from the regulatory treatment of sovereign debt (Acharya and Steffen, 2014, Lamas and Mencia, 2019).

Additionally, Lamas and Mencia (2019) find an inverse relationship between the bank's sovereign exposure and the country's *GDP* (increasing exposure when the *GDP* decreases and in the opposite direction). We consider variables for yield (*Yld*) and gross domestic product (*GDP*) (Battistini et al., 2013; Asonuma et al., 2015; Acharya and Steffen, 2015; Becker and Ivashina, 2017; Ongena et al., 2019; Lamas and Mencia, 2019; Rossi, 2019) to proxy for national wealth and economic outlook.

Table 3. Variables description

DEPENDENT VARIABLE	Notation	Classification		Data source	References
Total Securities to total assets	TSTA			SNL	Fратиани et Marchionne, (2016); Merler and Pisani-Ferry (2012); Buch et al., (2016)
EXPLANATORY VARIABLES	Notation	Classification	Hypotheses and expected signs	Data source	
Total Equity to Total Assets	TETA	Capitalization	H1(-)	SNL	Lamas et Mencia (2019), Buch et al. (2016), Ongena et al., (2016)Fratianni et Marchionne (2016), Affinito et al. (2016), Acharya Schnabl, (2010); Acharya and Steffen, (2014)
Problem Loans to total assets	PrLTA	Credit quality	H2 (+)	SNL	Lamas and Mencia (2019)
Net Customer Loans/Deposits (%)	NCLtoD	Liquidity	H3 (+)	SNL	Affinito et al. (2016)
ROAA (%)	ROAA	Profitability	H4 (-)	SNL	Angeloni and Wolff (2012), Lamas and Mencia (2019)
CONTROL VARIABLES	Notation	Classification		Data source	
Activity restriction index	Ares	Control Inst. Framework		World Bank	Barth, Caprio, and Levine (2004)
Capital stringency	CStr	Control Inst. Framework		World Bank	Barth, Caprio, and Levine (2004)
Official supervisory power	OSP	Control Inst. Framework		World Bank	Barth, Caprio, and Levine (2004)
Private Monitoring	PriM	Control Inst. Framework		World Bank	Barth, Caprio, and Levine (2004)
Gross Domestic Product	GDP	Control National Wealth and Economic Outlook		Statistical data warehouse ECB	Battistini et al., 2013; Asonuma et al., 2015; Acharya and Steffen, 2015; Becker and Ivashina, 2017; Ongena et al., 2019, Lamas and Mencia (2019)
Debt to GDP	DEBTGDP	Control National Wealth and Economic Outlook		Statistical data warehouse ECB	Battistini et al., 2013; Asonuma et al., 2015; Acharya and Steffen, 2015; Becker and Ivashina, 2017; Ongena et al., 2019, Lamas and Mencia (2019)
% Yield	Yld	Control National Wealth		Statistical data warehouse ECB	Battistini et al., 2013; Asonuma et al., 2015; Acharya and Steffen, 2015; Becker and Ivashina, 2017; Ongena et al., 2019, Lamas and Mencia (2019)
CONTROL VARIABLE	Notation	Classification		Data source	
LN Total Assets	TA	Control size		SNL	Fratianni et Marchionne (2016), Affinito et al. (2016)
Total Deposits from Customers to Total assets	TdfCTA	Control Business Model		SNL	Buch et al. (2016), Lamas and Mencia (2019)
Net Loans to Customers/Total assets	NTtCTA	Control Business Model		SNL	Affinito et al. (2016), Lamas et Mencia (2019), Buch et al. (2016), Ongena et al., (2016)
Net Interest Margin (%)	NiM	Lending Margins		SNL	(ECB, 2020)

## 4. Empirical analysis

### 4.1. Descriptive Statistics

We present the descriptive statistics for the variables in our model in Table 4. As can be noted from the table, the maximum number of observations is 1636. The average and median *TSTA* was 28%, presenting a modest variation. The mean *TETA* is 10%, showing that, on average, European small banks are well capitalized. Regarding *PrLTA*, the average ratio is 0.08% which is rather high, which could be since SNL-data base includes a broader scope beyond non-performing loans in their “problem loans” definition. Interestingly, the *NCLtoD* mean ratio is above 100%, which suggests liquidity issues in European small banks.

Table 4. Descriptive statistics of main explanatory variables

	TSTA	TETA	PrLTA	NCLtoD	ROAA
Observations	1636	1636	1636	1636	1636
Mean	0.28	0.10	0.08	1.0917	0.0024
Standard dev.	0.11	0.04	0.05	14.00	0.67
Min.	0.01	0.02	0.00	36.02	-0.461
25%	0.20	0.08	0.05	0.8534	0.0010
50%	0.28	0.09	0.08	1.0663	0.0025
75%	0.35	0.11	0.12	1.3003	0.0047
Max.	0.60	0.52	0.23	2.5123	0.0499

*This table provides the descriptive statistics for the sample. Specifically, we report total observations, the mean, standard deviation, quartiles, and maximum and minimum values of each variable. In Table 3, we provide a further description of the variables.*

### 4.2. Univariate analysis

We undertake a univariate analysis to examine the relationship between the *TSTA* and the different explanatory variables. To do this, we first divide our sample into two subsamples based on sovereign exposure. The high-sovereign-debt-exposure subsample contains institutions with above-average *TSTA*, whereas the low-sovereign-debt-exposure subsample contains institutions with below-average *TSTA*. Second, we run two-tailed t-tests under the null hypothesis that there are no differences in the means between institutions with higher and lower sovereign debt risk exposure.

The results of the univariate analysis, provided in Table 3, confirm our first and fourth hypotheses. *TETA* becomes statistically significant and presents a negative coefficient, indicating that banks with lower capital levels present higher sovereign debt exposure. We cannot, however, confirm our second, third and fourth hypotheses, as the results from credit quality and liquidity are not statistically significant.

Regarding the control variables, the differences in the means of *CStr* and *OSP* are statistically significant, suggesting that greater capital stringency leads to larger sovereign exposure, while supervisory power reduces banks' exposure to sovereign debt. Additionally, the coefficients for *Yld*, *GDP* and *DEBTGDP* become statistically significant, showing that greater *GDP* and lower *Yld* and *DEBTGDP* are associated with higher levels of sovereign debt.

In line with Affinito et al. (2016), *TA* and *TDfCTA* are negatively and significantly correlated with *TSTA*, suggesting that the funding structure and size of a bank can affect the sovereign exposure decision. Additionally, *NTtCTA* shows a statistically significant negative relationship with sovereign debt exposure. Finally, looking at the *NiM*, we realize that banks with higher lending margins are less prone to exposure to sovereign debt.

Table 5. Univariate analysis

	Observations above the average TSTA Mean	Observations below the average TSTA Mean	Diff means
NTtCTA	28.75364	44.34852	-15.595***
TETA	160.4624	169.14	-8.6776**
PrLTA	9.077	9.015	0.0622
NCLtoD	802.77	730.16	72.61
ROAA	72.0534	70.17857	1.87483
NiM	115.5121	139.7833	-24.2712***
Ares	4.059466	3.674877	0.3845
CStr	4.975728	4.564039	0.418***
OSP	7.339806	7.564039	-0.224233***
PriM	6.019417	5.922414	0.097003
GDP	55.8301	43.08744	12.7466***
DEBTGP	41.44053	42.87069	-1.43016***
Yld	44.16626	50.32759	-6.161***
TA	212.4927	224.2007	-11.708***
TDFCTA	31.98422	33.08251	-1.182***

Notes: The table reports the results of two-tailed t-tests for the null hypothesis that there-is no difference in the means between financial institutions with above and below *TSTA*. The “above the average” and “below the average” subsamples consist of financial institutions with *TSTA* below and above the median, respectively. Significance levels are indicated as follows: \*\*\*= significant at the 1% level; \*\*= significant at the 5% level; and \*= significant at the 10% level. In Table 3, we provide a further description of the variables.

#### 4.3. Correlation Matrix

In Table 6, we present the correlation matrix between the dependent and bank-specific variables. As can be noted from the table, *NCLtoD* is highly and negatively correlated with *TSTA*, indicating that illiquidity might lead to lower sovereign exposure, thus supporting hypothesis 3. The sign of the coefficients provides support for hypotheses 1 and 3; however, the table shows a positive correlation between *PrLTA* and *TSTA*, suggesting that the greater the ratio of non-performing loans is, the greater the sovereign exposure. Likewise, the positive correlation between *ROAA* and *TSATA* suggests that most profitable entities tend to accumulate more sovereign debt in their balance sheet, contrary to our expected relationship in hypothesis 4. In general, the correlation between explanatory variables is below 0.5; however, *ROAA* and *PrLTA* present high coefficients (-0.46), which indicates possible endogeneity issues that need to be addressed in our multivariate setting.

Table 6. Correlation matrix of main explanatory variables

	<i>TSTA</i>	<i>TETA</i>	<i>PrLTA</i>	<i>NCLtoD</i>	<i>ROAA</i>	<i>Ares</i>	<i>CStr</i>	<i>OSP</i>	<i>PrIM</i>	<i>GDP</i>	<i>DEBTGDP</i>	<i>Yld</i>	<i>TDfCTA</i>	<i>NTtCTA</i>	<i>NiM</i>
<i>TSTA</i>	1.00														
<i>TETA</i>	(0.11)	1.00													
<i>PrLTA</i>	0.05	(0.09)	1.00												
<i>NCLtoD</i>	(0.44)	0	0.23	1.00											
<i>ROAA</i>	0.09	0.27	(0.46)	(0.20)	1.00										
<i>Ares</i>	0.18	(0.05)	(0.01)	(0.08)	(0.16)	1.00									
<i>CStr</i>	0.30	(0.02)	(0.02)	0.06	(0.01)	0.89	1.00								
<i>OSP</i>	0.38	0.03	0.05	0.31	0.26	0.31	0.58	1.00							
<i>PrIM</i>	0.05	(0.03)	(0.00)	(0.02)	(0.04)	0.46	0.28	(0.02)	1.00						
<i>GDP</i>	(0.19)	0.03	(0.00)	(0.22)	(0.25)	0.01	(0.15)	(0.34)	(0.07)	1.00					
<i>DEBTGDP</i>	0.23	0.03	(0.03)	0.36	0.40	(0.17)	0.00	0.37	0.21	(0.67)	1.00				
<i>Yld</i>	(0.28)	(0.04)	(0.04)	(0.03)	0.10	(0.30)	(0.40)	(0.27)	0.05	(0.19)	0.32	1.00			
<i>TDfCTA</i>	(0.09)	0.04	0.07	(0.24)	(0.54)	0.37	0.26	(0.08)	0.08	0.24	(0.42)	(0.37)	1.00		
<i>NTtCTA</i>	(0.81)	(0.08)	0.16	0.12	0.10	(0.27)	(0.33)	(0.34)	(0.07)	0.13	(0.10)	0.29	(0.00)	1.00	
<i>NiM</i>	(0.16)	0.20	(0.13)	0.08	0.06	(0.16)	(0.22)	(0.16)	0.04	0.02	0.14	0.46	(0.03)	0.19	1.00

Notes: The table reports pairwise correlations between the dependent variable and main explanatory variables. In Table 3, we provide a further description of the variable

#### 4.4. Multivariate analysis

After we tested for univariate and bivariate relationships among our variables, we undertook a multivariate test. More specifically, we use the GMM estimator (Bover,1995; Blundell and Bond,1998) to analyse the main determinants of the sovereign debt exposure of small banks. In our analysis, we acknowledge that there are some potential omitted variables, such as corporate governance controls, which might lead to correlations between the error term and the explanatory variables. Thus, we might face an endogeneity issue. To overcome endogeneity concerns, we use the two-step estimation system-GMM estimator with finite-sample and corrected standard errors, as proposed by Windmeijer (2005). The GMM system controls for endogeneity using the lagged values of the explanatory variables as instruments. In our model, we consider bank-specific variables as endogenous and macroeconomic and regulatory variables as strictly exogenous variables (Delis and Staikouras, 2011). We include the lagged dependent variable, as previous sovereign debt exposure might drive future exposure. Finally, we apply the Arellano-Bond test to test for first- ( $AR_1$ ) and second order ( $AR_2$ ) serial correlation; we also implement Sargan overidentification tests. We estimate the following baseline equation:

$$TSTA_{i,j,t} = \alpha + \delta \cdot Y_{i,j,t-1} + \beta \cdot B_{i,j,t} + \gamma \cdot M_{j,t} + \theta \cdot R_{j,t-1} + \eta \cdot L_{i,j,t} + \epsilon_{i,j,t} \quad (1)$$

where  $TSTA$  represents the proportion of total securities over total assets and is our proxy for sovereign debt exposure of bank  $i$  in country  $j$  at year  $t$ ;  $TS_{i,j,t-1}$  represents its one-year lagged value of the dependent variable;  $B_{i,j,t}$  and  $M_{j,t}$  denote the bank-specific and macroeconomic variables, respectively;  $R_{j,t-1}$  refers to several bank regulation and supervision control variables;  $L_{i,j,t}$  refers to bank-specific control variables; and  $\delta$ ,  $\beta$ ,  $\gamma$ ,  $\theta$  and  $\eta$  are vectors of coefficient estimates. Finally,  $\epsilon_{i,j,t}$  is the disturbance term that contains an unobserved bank-specific effect ( $\eta_i$ ) and idiosyncratic error ( $v_{i,t}$ ).

Table 7 presents a summary of the coefficients and standard deviations of the  $TSTA$  determinants. The results of the system-GMM estimation show a highly significant and positive correlation between the

lagged dependent variable and *TSTA*, indicating that the current levels of total securities are highly affected by the prior level of total securities. This result confirms the dynamic nature of the model.

According to the results for our main explanatory variables, hypothesis 1 is confirmed. The coefficient of *TETA* is negatively and significantly correlated with *TSTA*, thus confirming hypothesis 1. This implies a moral hazard and the so-called “gamble for resurrection” strategy, suggesting that undercapitalized institutions tend to increase sovereign debt exposure that requires little or zero capital to benefit from high-yield government bonds. (Acharya and Steffen, 2014; Affinito et al. 2016). This result might be motivated for a lack of alternatives of small banks to increase capital. The reasons behind this might have diverse nature but, due to the importance these institutions have for the local economy, it is important to acknowledge this phenomenon and supervisors give alternatives for small banks to capitalize (instead of assuming an extra risk via sovereign exposure). Our results are also in line with Popov and van Horen (2013), who highlight that bank have incentives to keep sovereign debt in their balance sheet, as they have beneficial regulatory treatment that can help to maintain capital levels (Lang and Schröder, 2015; Bonner, 2016).

Regarding hypothesis 2, surprisingly, we find a negative and significant correlation between *PrLTA* and *TSTA*, contrary to the expected results according to previous literature (Bolton and Jeanne, 2011 and Lamas and Mencía, 2019), suggesting that the higher the credit quality is, the higher the sovereign debt exposure. This finding constitutes a significant contribution to the literature, although it requires further empirical tests, as it indicates that factors that explain the sovereign debt exposure of LSIs differ from those of SIs, on which most of the literature is focused. According to our results, LSIs with better-allocated credit risk portfolios might be more prone to invest in sovereign debt.

Hypotheses 3 and 4 are not confirmed since the coefficients of *NCLtoD* and *ROAA* are statistically insignificant. We can conclude that for LSIs, neither bank liquidity nor profitability determines sovereign debt exposure and that banks suffering a drain in liquidity might not potentially increase their investment in sovereign debt exposure (Gennaioli et al; 2013).

Regarding the regulatory control variables, the coefficients of *Ares*, *CStr* and *OSP* are statistically significant. *Ares* is negatively related to *TSTA*, which implies that fewer regulatory restrictions allow institutions to exploit economies of scale and scope, increasing the franchise value of banks and therefore augmenting incentives for banks to have more prudent behavior coupled with lower levels of sovereign exposure (Barth, Caprio and Levine; 2004). *CStr* and *OSP* are positively correlated with *TSTA*, suggesting that the intensity of banking supervision does not disincentivize exposure to sovereign debt. Moreover, as the authority of supervisors increases, institutions become more predisposed to have large sovereign exposure (Barth, Caprio and Levine; 2004).

Regarding macroeconomic controls, the coefficient of *Yld* becomes statistically significant and negatively correlated with *TSTA*, which indicates that the “self-preservation hypothesis<sup>27</sup>” is not valid. Moreover, the negative coefficient of *Yld* indicates that small banks do not pursue reach-for-yield behavior<sup>28</sup> (Lamas and Mencía, 2019). This result is in line with Andreeva and Vlassopoulos (2016), who also illustrate that banks do not pursue high-risk bonds, as they understand that there is a close link between sovereign debt and banks’ own insolvency. In conclusion, we can say that banks adjust their lending behavior and exposure when sovereign bonds are under stress (Bolton and Jeanne; 2011).

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<sup>27</sup> This refers to the scenario in which institutions invest in distressed sovereign exposures (with high yields) to reduce the probability of sovereign default, leading to negative spill-overs and implications of sovereign risk for their own performance (ESRB, 2015).

<sup>28</sup> Reach-for-yield is understood as in Becker and Ivashina (2015) and Lamas and Mencía (2019), who study financial and insurance companies’ preferences to hold higher-yielding bonds within the same regulatory risk category.

Finally, concerning ban-specific controls, we find a negative and significant correlation between  $TdfCTA$  and  $TSTA$ , in line with Buch et al. (2016), who establish that modelling banks with portfolio managers can optimize their results by diversifying the risk by investing in assets other than sovereign bonds.

$AR_1$  and  $AR_2$  test for first- and second-order serial correlation, respectively, using residuals in first differences, asymptotically distributed as  $N(0,1)$  under the null hypothesis of no serial correlation. We verify that the instruments are statistically valid using a Sargan-Hansen test of overidentifying restrictions. We provide the coefficients of the instrumental analyses and degrees of freedom in parentheses.

Table 7. GMM-System *TSTA*

	GMM-System
TSTA-1	0.23759***
	-0.041
TETA	-0.0253***
	-0.008
PrLTA	-0.1957***
	-0.068
NCLtoD	0
	0
ROAA	-0.002
	-0.01
Ares	-5.154**
	-2.24
CStr	5.917**
	-2.814
OSP	0.468*
	-0.27
PriM	0.079
	-0.817
GDP	0.026
	-0.029
DEBTGDP	-0.008
	-0.04
Yld	-0.014***
	-0.014
TA	0
	-0.006
TdfCTA	-0.126***
	-0.032
NTtCTA	-0.6418***
	-0.056
NiM	0.006
	-0.008
TSTA-1	0.23759***
	-0.041
TETA	-0.0253***
	-0.008
PrLTA	-0.1957***
	-0.068
NCLtoD	0
	0

Notes: The table reports the determinants of TSTA exposure for the period 2010-2017 using the GMM estimator developed by Arellano and Bover (1995) and Blundell and Bond (1998). The risk characteristics are classified using four main components (Capitalization, Credit quality, Liquidity and Profitability). The bank-level variables have been considered endogenous (PrLTA, NCLtoD, ROAA, NiM, TA, TdfCTA and NTtCTA), while the macroeconomic/regulatory variables have been considered exogenous (Ares, CStr, OSP, GDP, DEBTGDP and Yld).

We report heteroskedasticity-consistent asymptotic standard errors in parentheses, and significance levels are indicated as follows: \*\*\*= significant at the 1% level; \*\*= significant at the 5% level; and \*= significant at the 10% level. Hansen is a test of the over-identifying restrictions, asymptotically distributed as  $\chi^2$  under the null hypothesis of no correlation between the instruments and the error term, with degrees of freedom in parentheses. Sargan tests and the Difference-in-Hansen tests of exogeneity validate the instruments. *In Table 3, we provide a further description of the variables.*

#### **4.5. Extension and further robustness checks**

To provide robustness to our system-GMM results, we further employ an ordinary least squares (OLS) regression. Table 8 shows the results of the OLS regression. As can be noted from the table, the results resemble our original ones, thus confirming hypothesis 1 and rejecting hypothesis 2. Similar to our original system-GMM regression, we find a negative relationship between *TETA* and *PrLTA* and *TSTA*. These results first suggest that less capitalized institutions tend to have a larger appetite for sovereign debt securities. Second, contrary to larger banks, LSIs with better credit quality are more prone to increase their sovereign debt exposure. Hypotheses 3 and 4 cannot be confirmed either. Regarding the regulation and macroeconomic controls, we find consistency in the results, as the coefficients of *PrIM*, *Yld* and *GDP* become statistically significant. Moreover, the OLS regression provides additional significant macroeconomic variables, such as *Ares* and *OSP*. The coefficients on the microeconomic control variables do not differ from the system-GMM results with the exception of *TA* and *NiM*. *TA* becomes positively and statistically significantly correlated with *TSTA*, suggesting that larger banks tend to hold proportionally higher amounts of sovereign debt, similar to Affinito et al. (2017). However, the coefficient of *NiM* is positively and significantly correlated with *TSTA*, indicating that institutions with larger interest margins are more likely to have a larger exposure to sovereign debt.

Table 8 OLS TSTA

	OLS
TETA	-0.016*** (0.0024)
PrLTA	-0.076** (0.032)
NCLtoD	0 (0)
ROAA	-0.007 (0.006)
Ares	-3.912*** (0.56)
CStr	3.987*** (0.726)
OSP	0.410*** (0.109)
PriM	0.476 (0.396)
GDP	0.063*** (0.012)
DEBTGDP	-0.0006 (0.018)
Yld	-0.066*** (0.011)
TA	0.004** (0.002)
TDfCTA	-0.077*** (0.014)
NTtCTA	-0.722*** (0.148)
NiM	0.013*** (0.004)
AR <sub>1</sub>	-
AR <sub>2</sub>	-
Sargan	-
Hansen	-
R <sup>2</sup>	0.7074
F	
Number of observations	1636

*Notes:* The table reports the determinants of TSTA exposure across the period 2010-2017 using alternative model specifications for our baseline equations. The risk characteristics are classified using four main components (Capitalization, Credit quality, Liquidity and Profitability). R<sup>2</sup> is the proportion of variation in the dependent variable explained by the model. Significance levels are indicated as follows: \*\*\*= significant at the 1% level; \*\*= significant at the 5% level; and \*= significant at the 10% level. *In Table 3, we provide a further description of the variables.*

As an additional robustness check, we run the model by removing observations from Italian banks, which account for more than  $\frac{1}{4}$  of our observations. We undertake an OLS regression because due to the number of observations available, the GMM system cannot be applied. Table 9 shows the results of the OLS regression without Italian banks. As the table depicts, the results are aligned with the original ones as of those of previous robustness tests. We verify a negative relationship between bank capitalization and sovereign debt exposure and a positive and significant relationship between the credit quality of a bank and its sovereign debt exposure. Contrary to the expected results and previous models, the coefficient of ROAA becomes positive and significant at 10%.

Table 9 OLS TSTA no IT banks

OLS	
TETA	-0.0478*** (0.016)
PrLTA	-0.4269*** (0.20)
NCLtoD	0 (0.0004)
ROAA	0.0351* (0.019)
Ares	-0.0288*** (0.0096)
CStr	0.0284*** (0.0093)
OSP	0.0002 (0.002)
PriM	-0.0052 (0.006)
GDP	-0.0011 (0.002)
DEBTGDP	0.0001 (0.0001)
Yld	-0.0054* (0.003)
TA	0.0705*** (0.014)
TDfCTA	0.0015* (0.0008)
NTtCTA	-0.658*** (0.069)
NiM	0.0224** (0.01)

*Notes: The table reports the determinants of TSTA exposure (excluding IT banks) across the period 2010-2017 using alternative model specifications for our baseline equations. The risk characteristics are classified using four main components (Capitalization, Credit quality, Liquidity and Profitability); see Table 2 for a description of the independent variables. R2 is the proportion of variation in the dependent variable explained by the model.*

## 5. Conclusions

In this paper, we study the determinants of the sovereign debt exposure of European LSIs from 2010 to 2017, covering both the financial crisis of 2008 and the leading sovereign crisis of 2012. We identify the main bank-specific explanatory variables: *Capitalization*, *Credit quality*, *Liquidity* and *Profitability*. We further control for other microeconomic, macroeconomic, and regulatory variables.

We contribute to the existing literature by showing significant differences between LSIs and SIs in the factors that lead financial institutions to increase their sovereign debt exposure. Supervision needs to be tied up to the bank's idiosyncrasies, considering its differences in size, behavior, or riskiness. Through this analysis we increase the understanding of the LSI ties to the sovereign risk. With it, we allow supervisors of LSI to not only enforcing standardized regulations with regards of banking supervision but to understand how the links between LSI sovereign exposure work. In this way supervisions could exercise judgment and discretion to identify and correct threats affecting the supervised banks.

We further show that capitalization and credit quality determine the sovereign debt exposure of LSIs. In fact, our results show that lower levels of capital increase sovereign debt exposure. Unexpectedly, credit quality is negatively related to sovereign debt exposure, suggesting that institutions with greater credit quality tend to have larger sovereign debt exposure. This last finding suggests that LSIs and SIs exhibit different behaviors.

More specifically, our results confirm our first hypothesis, showing that weakly capitalized banks can apply the so-called "gamble for resurrection" strategy (Freixas et al, 2003; Lang and Schröder, 2015; Bonner, 2016). Through this strategy, low-capitalized financial institutions increase their sovereign debt exposure, which requires little or zero capital, to benefit from high-yield government bonds (Acharya and Steffen, 2014; Affinito et al. 2016). Our results are in line with the scientific literature focused on the European sovereign debt crisis between 2010 and 2012, which states that distressed

banks tend to take advantage of the existing macroprudential regulations to improve their capitalization (Acharya and Steffen 2015). However, our results further show a negative and significant relationship between the ratio of nonperforming loans and sovereign debt exposure. This finding suggests that LSIs with stronger credit quality tend to invest in sovereign securities, contrary to the opposite behavior observed in larger banks.

According to our results, sovereign debt exposure of LSIs is also driven by regulatory factors, such as *Are*, *Cstr*, and *Osp*. We find a direct relationship, as regulatory activity restrictions can disincentivize sovereign debt exposure. However, higher *Cstr* and *Osp* might harm the accountability of financial institutions for sovereign debt exposure (Acharya and Steffen, 2014; Lenarcic et al., 2016; Lang and Schröder, 2015; Bonner, 2016). Regarding macroeconomic factors, we find a negative relationship between *Yld* and the sovereign debt exposure of LSIs, which implies that there is no moral suasion from governments under distress. These results further indicate that LSIs, unlike larger financial institutions, do not follow a reach-for-yield strategy<sup>11</sup>, as they reduce exposure to sovereign debt when there is a distressed macroeconomic scenario.

We acknowledge that our study has limitations. We disregard observations for institutions with a different accounting regime, as they cannot be compared with the rest of the sample. Additionally, our proxy for debt exposure includes not only sovereign bonds but also total securities for LSIs. Nevertheless, debt securities constitute a relevant part of LSIs' assets, in which sovereign bonds are the prevailing asset class listed on LSIs' balance sheets (ECB, 2020). Further research on this topic could focus on different implications of sovereign risk for small European banks and how this could be reflected in prudential regulations and the principle of proportionality.

Overall, our empirical findings provide evidence that can help regulators develop prudential supervision to closely monitor LSIs' sovereign debt exposure. We show that LSIs have different

incentives from larger banks to increase their sovereign debt exposure. Despite recent concerns regarding the inherent risk of sovereign risk exposure (BIS, 2017), regulations maintain that sovereign debt is a risk-free asset<sup>29</sup>. Consequently, the board of directors can encourage unethical behavior to capitalize the institution at the expense of the beneficial treatment of sovereign debt or to maximize results through sovereign risk exposure (capital requirements directive). Our work provides a better understanding of the behavior and rationale behind sovereign investment decisions made by LSIs. We verify moral hazard behavior among LSIs, as poorly capitalized banks use their sovereign exposure to generate profits and improve capital ratios (Acharya and Steffen, 2015). Our conclusions are, thus, of interest for supervisors to further develop macroprudential regulations that take into consideration that capitalization and credit quality determine the sovereign debt exposure of LSIs.

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<sup>29</sup> Under current regulations, sovereign debt exposure has no concentration limits and a zero-risk weight, which leaves the definition of the risk appetite towards sovereign debt exposure to the discretion of bank directors.

## References:

- (Acharya and Steffen, 2014) Acharya, Viral & Steffen, Sascha. 2014. The 'Greatest' Carry Trade Ever? Understanding Eurozone Bank Risks. SSRN Electronic Journal. 10.2139/ssrn.2257665.
- (Acharya and Steffen, 2015) Acharya, Viral and Steffen, Sascha. 2015. The "greatest" carry trade ever? Understanding eurozone bank risks, *Journal of Financial Economics*, 115, issue 2, p. 215-236.
- (Acharya et al., 2011) ACHARYA, V.V. and VISWANATHAN, S. (2011), Leverage, Moral Hazard, and Liquidity. *The Journal of Finance*, 66: 99-138. doi:10.1111/j.1540-6261.2010.01627.x
- (Affinito et al. 2016) Affinito, Massimiliano and Albareto, Giorgio and Santioni, Raffaele, Purchases of Sovereign Debt Securities by Italian Banks During the Crisis: The Role of Balance-Sheet Conditions (June 6, 2016). Bank of Italy Occasional Paper No. 330, Available at SSRN: <https://ssrn.com/abstract=2844705> or <http://dx.doi.org/10.2139/ssrn.2844705>
- (Affinito et al., 2016). Affinito, Massimiliano & Albareto, Giorgio & Santioni, Raffaele. (2016). Purchases of Sovereign Debt Securities by Italian Banks During the Crisis: The Role of Balance-Sheet Conditions. SSRN Electronic Journal. 10.2139/ssrn.2844705.
- (Agoraki, et al., 2011) Agoraki, M.E. K., Delis, M. D., & Pasiouras, F. (2011). Regulations, competition and bank risk-taking in transition countries. *Journal of Financial Stability*, 7, 38–48.
- (Agresti et al, 2008) Agresti, Anna Maria and Baudino, Patrizia and Poloni, Paolo, The ECB and IMF Indicators for the Macro-Prudential Analysis of the Banking Sector: A Comparison of the Two Approaches (November 7, 2008). ECB Occasional Paper No. 99, Available at SSRN: <https://ssrn.com/abstract=1144486>
- (Albertazzi et al, 2014) Albertazzi, Ugo and Ropele and Tiziano, Sene and Gabriele and Signoretti, Federico M. (2014). The impact of the sovereign debt crisis on the activity of italian banks. *Journal of Banking & Finance*, 46, 387-402. doi:<https://doi.org/10.1016/j.jbankfin.2014.05.005>
- (Altavilla et al, 2017) Altavilla, Carlo and Boucinha, Miguel and Peydró, José-Luis.2017. "Monetary Policy and Bank Profitability in a Low Interest Rate Environment," CSEF Working Papers 486, Centre for Studies in Economics and Finance (CSEF), University of Naples, Italy.
- (Andreeva and Vlassopoulos, 2016) Vlassopoulos, Thomas & C. Andreeva, Desislava, 2016. "Home bias in bank sovereign bond purchases and the bank-sovereign nexus," Working Paper Series 1977, European Central Bank.
- (Andreeva and Vlassopoulos, 2016) Vlassopoulos, Thomas & C. Andreeva, Desislava, 2016. "Home bias in bank sovereign bond purchases and the bank-sovereign nexus," Working Paper Series 1977, European Central Bank.

- (Angeloni and Wolff, 2012 ) Angeloni, Chiara and Wolff, Guntram, (2012), Are banks affected by their holdings of government debt?, Working Papers, Bruegel.
- (Arellano and Bond, 1991) Arellano, Manuel and Bond, Stephen, (1991), Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations, *Review of Economic Studies*, 58, issue 2, p. 277-297, <https://EconPapers.repec.org/RePEc:oup:restud:v:58:y:1991:i:2:p:277-297..>
- (Arellano and Bover, 1995) Arellano, Manuel and Bover, Olympia, (1995), Another look at the instrumental variable estimation of error-components models, *Journal of Econometrics*, 68, issue 1, p. 29-51, <https://EconPapers.repec.org/RePEc:eee:econom:v:68:y:1995:i:1:p:29-51>.
- (Ari 2017) Ari, A. (2018). Sovereign risk and bank risk-taking.73 / April 2018 Retrieved from <http://dx.publications.europa.eu/10.2849/528549>
- (Asonuma et al, 2015) Asonuma, Tamon & Bakhache, Said & Hesse, Heiko. (2015). Is Banks Home Bias Good or Bad for Public Debt Sustainability?. *SSRN Electronic Journal*. 10.2139/ssrn.2578837.
- (Asonuma et al., 2015) Asonuma, Tamon and Bakhache, Said and Hesse, Hesse. 2015. Is banks' home bias good or bad for public debt sustainability?. Washington, DC: IMF. doi:10.5089/9781498323505.001
- (Barth, Caprio, and Levine, 2004) Barth, James & Caprio, Gerard & Levine, Ross. (2004). Bank Regulation and Supervision: What Works Best?. *Journal of Financial Intermediation*. 13. 205-248. 10.1016/j.jfi.2003.06.002.
- (Baselga-Pascual et al, 2015). Baselga-Pascual, Laura, Trujillo-Ponce, Antonio and Cardone-Riportella, Clara, (2015), Factors influencing bank risk in Europe: Evidence from the financial crisis, *The North American Journal of Economics and Finance*, 34, issue C, p. 138-166, <https://EconPapers.repec.org/RePEc:eee:ecofin:v:34:y:2015:i:c:p:138-166>.
- (Battistini et al, 2013) Battistini, Niccolò and Pagano, Marco and Simonelli, Saverio. 2013. Systemic Risk and Home Bias in the Euro Area, *European Economy. Economic Papers*.
- (Battistini et al. 2013) Battistini, N., Pagano, M., & Simonelli, S. (2013). Systemic risk and home bias in the euro area. Brussels: Europ. Comm., Directorate-General for Economic and Financial Affairs. doi:10.2765/43547
- (Battistini et al., 2013) Battistini, Niccolò & Pagano, Marco & Simonelli, Saverio. (2013). Systemic Risk and Home Bias in the Euro Area, *European Economy. Economic Papers*.
- (Becker and Ivashina 2017) Becker, Bo & Ivashina, Victoria. 2018. Financial Repression in the European Sovereign Debt Crisis\*. *Review of Finance*. 22. 83-115. 10.1093/rof/rfx041.
- (Becker and Ivashina, 2017) Asonuma, Tamon and Bakhache, Said and Hesse, Heiko, Is Banks' Home Bias Good or Bad for Public Debt Sustainability? (February 15, 2015). IMF Working Paper WP/15/44, Available at

SSRN: <https://ssrn.com/abstract=2578837> or <http://dx.doi.org/10.2139/ssrn.2578837>

- (Bellia et al .(2019) Mario Bellia & Ludovic Calès & Lorenzo Frattarolo & Andreea Maerean & Daniel P. Monteiro & Marco Petracco Guidici & Lukas Vogel, 2019. "The Sovereign-Bank Nexus in the Euro Area: Financial & Real Channels," European Economy - Discussion Papers 2015 - 122, Directorate General Economic and Financial Affairs (DG ECFIN), European Commission.
- (Bertay et al. 2017) Bertay, Ata Can and Huizinga, Harry. 2017. Have european banks actually changed since the start of the crisis? an updated assessment of their main structural characteristics. European Parliament. Provided at the request of the Economic and Monetary Affairs Committee. Directorate- General for Internal Policies. Available [https://www.europarl.europa.eu/RegData/etudes/IDAN/2017/602097/IPOL\\_IDA\(2017\)602097\\_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/IDAN/2017/602097/IPOL_IDA(2017)602097_EN.pdf)
- (Bertay et al., 2017) Bertay, Ata and Gong, Di and Wagner, Wolf. 2017. Securitization and economic activity: The credit composition channel, Journal of Financial Stability, 28, issue C, p. 225-239.
- (Berti et al. 2012) Berti, Katia & Salto, Matteo & Lequien, Matthieu. (2012). An early-detection index of fiscal stress for EU countries. European Commission, DG ECFIN - European Economy Economic Paper.
- (BIS , 2011) Bank for International Settlements (2011). The impact of sovereign credit risk on bank funding conditions Bank for International Settlements. Retrieved from <http://econpapers.repec.org/bookchap/bisbiscgf/43.htm>
- (BIS , 2013) Bank for International Settlements. 2013 Sovereign Risk: A World Without Risk-Free Assets? (July 2013). BIS Paper No. 72, Available at SSRN: <https://ssrn.com/abstract=2420000>
- (BIS , 2018) Bank for International Settlements. 2011. The regulatory treatment of sovereign exposures. Retrieved from <https://www.bis.org/bcbs/publ/d425.pdf>
- (BIS, 2017) Bank for International Settlements. (2017, December). The regulatory treatment of sovereign exposures. Available at <https://www.bis.org/bcbs/publ/d425.pdf> (Acceded 15-March 2018)
- (Blum, 2008) Blum, Jürg, (2008), Why 'Basel II' may need a leverage ratio restriction, Journal of Banking & Finance, 32, issue 8, p. 1699-1707.
- (Blum, 2008) Blum, Jürg, (2008), Why 'Basel II' may need a leverage ratio restriction, Journal of Banking & Finance, 32, issue 8, p. 1699-1707, <https://EconPapers.repec.org/RePEc:eee:jbfina:v:32:y:2008:i:8:p:1699-1707>.
- (Blundell and Bond, 1998) Blundell, Richard & Bond, Stephen, 1998. "Initial conditions and moment restrictions in dynamic panel data models," Journal of Econometrics, Elsevier, vol. 87(1), pages 115-143, August.

- (Bolton and Jeanne 2011) Bolton, Patrick and Jeanne, Olivier, (2011), Sovereign Default Risk and Bank Fragility in Financially Integrated Economies, IMF Economic Review, 59, issue 2, p. 162-194.
- (Bolton and Jeanne, 2011 ) Bolton, Patrick and Jeanne, Olivier, (2011), Sovereign Default Risk and Bank Fragility in Financially Integrated Economies, IMF Economic Review, 59, issue 2, p. 162-194.
- (Bonner, 2016) BONNER, Clemens. 2016, Preferential Regulatory Treatment and Banks' Demand for Government Bonds. Journal of Money, Credit and Banking, 48: 1195-1221. doi:10.1111/jmcb.12331
- (Broner et al., 2013) Broner, Fernando and Erce, Aitor and Martin, Alberto & Ventura, Jaume, 2014. "Sovereign debt markets in turbulent times: Creditor discrimination and crowding-out effects," Journal of Monetary Economics, Elsevier, vol. 61(C), pages 114-142
- (Brunnermeier et al. 2016) "Brunnermeier, Markus K., Luis Garicano, Philip R. Lane, Marco Pagano, Ricardo Reis, Tano Santos, David Thesmar, Stijn Van Nieuwerburgh, and Dimitri Vayanos. 2016. ""The Sovereign-Bank Diabolic Loop and ESBies."" American Economic Review, 106 (5): 508-12.  
DOI: 10.1257/aer.p20161107"
- (Buch et al. 2016) Buch, C. M., Koetter, M., and Ohls, J. (2016a). Banks and sovereign risk: A granular view. Journal of Financial Stability, 25, 1-15. doi:10.1016/j.jfs.2016.05.002
- (Buch et al. 2016) Buch, Claudia, Koetter, Michael and Ohls, Jana, (2016), Banks and sovereign risk: A granular view, Journal of Financial Stability, 25, issue C, p. 1-15.
- (Caprio and Levine; 2004) Barth, James, Caprio, Gerard and Levine, Ross, (2004), Bank regulation and supervision: what works best?, Journal of Financial Intermediation, 13, issue 2, p. 205-248, <https://EconPapers.repec.org/RePEc:eee:jfinin:v:13:y:2004:i:2:p:205-248>.
- (Correa et Sapriza, 2014) Correa, Ricardo and Horacio Sapriza, 2014. "Sovereign Debt Crises," International Finance Discussion Papers1104, Board of Governors of the Federal Reserve System (U.S.), revised 21 May 2014.
- (Delis and Staikouras, 2011) Delis, Manthos and Staikouras, Panagiotis K., (2011), Supervisory Effectiveness and Bank Risk, Review of Finance, 15, issue 3, p. 511-543, <https://EconPapers.repec.org/RePEc:oup:revfin:v:15:y:2011:i:3:p:511-543>.
- (Dell'Ariccia et al; 2018) Dell'Ariccia, Giovanni & Peria, Maria & Igan, Deniz & Awadzi, Elsie & Dobler, Marc & Sandri, Damiano. 2018. Trade-offs in Bank Resolution. Staff Discussion Notes. 18. 1. 10.5089/9781484341001.006.
- (Demirgüç-Kunt and Huizinga, 2010) Demirguc-Kunt, Asli and Huizinga, Harry, (2010), Bank activity and funding strategies: The impact on risk and returns, Journal of Financial Economics, 98, issue 3, p. 626-650, <https://EconPapers.repec.org/RePEc:eee:jfinec:v:98:y:2010:i:3:p:626-650>.

- (Demirgüç-Kunt et al. 2013), Demirguc-Kunt, Asli, Detragiache, Enrica and Merrouche, Ouarda, (2013), Bank Capital: Lessons from the Financial Crisis, Journal of Money, Credit and Banking, 45, issue 6, p. 1147-1164, <https://EconPapers.repec.org/RePEc:mcb:jmoncb:v:45:y:2013:i:6:p:1147-1164>.
- (Demirgüç-Kunt, et al. 2013)Demirguc-Kunt, Asli, Detragiache, Enrica and Merrouche, Ouarda, (2013), Bank Capital: Lessons from the Financial Crisis, Journal of Money, Credit and Banking, 45, issue 6, p. 1147-1164.
- (Desislava et al., 2019) Desislava C. Andreeva and García-Posada, Miguel 2019. "The impact of the ECB's targeted long-term refinancing operations on banks' lending policies: the role of competition," Working Papers 1903, Banco de España; Working Papers Homepage.
- (Dieckmann and Plank, 2010)Dieckmann, Stephan and Plank, Thomas. 2011. Default Risk of Advanced Economies: An Empirical Analysis of Credit Default Swaps during the Financial Crisis. Political Economy: Structure & Scope of Government eJournal.
- (Dieckmann and Plank, 2010)Dieckmann, Stephan and Plank, Thomas, (2012), Default Risk of Advanced Economies: An Empirical Analysis of Credit Default Swaps during the Financial Crisis, Review of Finance, 16, issue 4, p. 903-934, <https://EconPapers.repec.org/RePEc:oup:revfin:v:16:y:2012:i:4:p:903-934>.
- (ECB, 2017) European Central Bank (2018) SSM Supervisory Manual European banking supervision: functioning of the SSM and supervisory approach Retrieved from <https://www.bankingsupervision.europa.eu/ecb/pub/pdf/ssm.supervisorymanual201803.en.pdf?42da4200dd38971a82c2d15b9ebc0e65>
- (ECB, 2018) European Central Bank. 2018.The risk report on less significant institutions (LSIs). European Central Bank. Available at <https://www.bankingsupervision.europa.eu/ecb/pub/html/ssm.lisriskreport202001~48ecda4549.en.html>. Accessed 3 October 2020
- (ECB, 2020) European Central Bank. 2018.The risk report on less significant institutions (LSIs). European Central Bank. Available at <https://www.bankingsupervision.europa.eu/ecb/pub/html/ssm.lisriskreport202001~48ecda4549.en.html#toc1> . Accessed 3 October 2020
- (ECB, 2020) European Central Bank. (2020, September 18). ECB oversight of LSIs. European Central Bank - Banking Supervision. <https://www.bankingsupervision.europa.eu/banking/lis/html/index.en.html>
- (Erce, 2015) Erce, Aitor. 2015. Bank and Sovereign Risk Feedback Loops. SSRN Electronic Journal. 10.2139/ssrn.2643953.
- (ESRB, 2015) ESRB. 2015. Report on the regulatory treatment of sovereign exposures. Retrieved from <https://www.esrb.europa.eu/pub/pdf/other/esrbreportregulatorytreatmentsovereignexposures032015.en.pdf>
- (European Comission, 2007) European Comission. Quarterly report on the euro area. 2007. Quarterly Report on the Euro Area (Online), 6, 3 Retrieved from <http://bookshop.europa.eu/uri?target=EUB:NOTICE:KCAK07003:EN:HTML>

- (Farhi and Tirole; 2015) Farhi, Emmanuel, & Tirole, Jean (2015). Liquid bundles. *Journal of Economic Theory*, 158, 634-655. doi:<https://doi.org/10.1016/j.jet.2014.09.002>
- (Farhi and Tirole; 2018) Farhi, Emmanuel & Tirole, Jean. (2018). Deadly Embrace: Sovereign and Financial Balance Sheets Doom Loops. *Review of Economic Studies*. 85. 1781-1823. 10.1093/restud/rdx059.
- (Fратиanni et Marchionne, 2016) Fratianni, Michele and Marchionne, Francesco. 2017. Bank asset reallocation and sovereign debt. *Journal of International Financial Markets, Institutions and Money*, 47, 15-32. doi:<https://doi.org/10.1016/j.intfin.2016.11.011>
- (Freixas et al, 2003) Freixas, Xavier & Rochet, Jean-Charles & Parigi, Bruno. (2000). Systemic Risk, Interbank Relations, and Liquidity Provision by the Central Bank.. *Journal of Money, Credit and Banking*. 32. 611-38.
- (Gennaioli et al; 2013) GENNAIOLI, Nicola., SHLEIFER, Andrei. and VISHNY, Robert.W. (2013), A Model of Shadow Banking. *The Journal of Finance*, 68: 1331-1363. doi:10.1111/jofi.12031
- (Gennaioli et al; 2018) Gennaioli, Nicola and Alberto Martin and Stefano Rossi. 2019. Banks, government Bonds, and Default: What do the data Say? *Journal of Monetary Economics*. Volume 98, 2018. Pages 98-113. ISSN 0304-3932. <https://doi.org/10.1016/j.jmoneco.2018.04.011>. (<http://www.sciencedirect.com/science/article/pii/S0304393218302125>)
- (Gennaioli et al. 2013) Gennaioli, Nicola & Shleifer, Andrei & Vishny, Robert. (2011). A Model of Shadow Banking. *The Journal of Finance*. 68. 10.2139/ssrn.2133418.
- (Grigorian and Manole, 2016) Grigorian, David & Manole, Vlad. (2016). Sovereign Risk and Deposit Dynamics: Evidence from Europe. *IMF Working Papers*. 16. 1. 10.5089/9781498381833.001.
- (Grigorian and Manole, 2016) Grigorian, David. 2002. Determinants of Commercial Bank Performance in Transition: An Application of Data Envelopment Analysis. *IMF Working Papers*. 02. 10.1057/palgrave.ces.8100129.
- (Jassaud, 2014) Jassaud, Nadege, Reforming the Corporate Governance of Italian Banks (September 2014). *IMF Working Paper No. 14/181*, Available at SSRN: <https://ssrn.com/abstract=2513266>
- (Kok and Schepens 2013) Kok, Christoffer and Schepens, Glenn, (2013), Bank reactions after capital shortfalls, No 250, Working Paper Research, National Bank of Belgium.
- (Kok and Schepens, 2013) Kok, Christoffer and Schepens, Glenn, (2013), Bank reactions after capital shortfalls, No 250, Working Paper Research, National Bank of Belgium, <https://EconPapers.repec.org/RePEc:nbb:reswpp:201312-250>.
- (Lamas and Mencía 2019) Lamas, Matías and Mencía, Javier. 2019. What drives sovereign debt portfolios of banks in a crisis context?. Frankfurt am Main, Germany: European Systemic Risk Board. doi:10.2849/619802

- (Lang and Schröder, 2015) Lang, Michael & Schröder, Michael, 2014. "What drives the demand of monetary financial institutions for domestic government bonds? Empirical evidence on the impact of Basel II and Basel III," ZEW Discussion Papers 14-123, ZEW - Leibniz Centre for European Economic Research.
- (Langedijk and Fontana, 2019) Langedijk, Sven and Alessandro Fontana. 2019. "The Bank-Sovereign Loop and Financial Stability in the Euro Area," Working Papers 2019-10, Joint Research Centre, European Commission (Ispra site).
- (Langfield and Pagano, 2016) Langfield, Sam and Pagano, Marco. 2016 Bank bias in Europe: effects on systemic risk and growth, *Economic Policy*, Volume 31, Issue 85, January 2016, Pages 51–106, <https://doi.org/10.1093/epolic/eiv019>
- (Lanotte et al., 2016) Lanotte, Michele and Giacomo Manzelli and Anna Maria Rinaldi and Marco Taboga and Pietro Tommasino. 2016. "Easier said than done? Reforming the prudential treatment of banks' sovereign exposures," *Questioni di Economia e Finanza (Occasional Papers)* 326, Bank of Italy, Economic Research and International Relations Area.
- (Lenarcic et al, 2016) Lenarčič, Andreja and Mevis, Dirk and Siklós, Dóra. 2016. Tackling sovereign risk in European banks. *European Stability Mechanism, Discussion Paper Series/1*. Available : [https://www.esm.europa.eu/sites/default/files/21032016\\_esm\\_discussionpaper1\\_final.pdf](https://www.esm.europa.eu/sites/default/files/21032016_esm_discussionpaper1_final.pdf) (accessed 15 July 2020)
- (Lenarcic et al, 2016) Lenarcic, Andreja and Mevis, Dirk and Siklos Dora. Tackling sovereign risk in European banks. *ESM Discussion Paper Series, (1)*, 2016.
- (Marco and Macchiavelli, 2015) De Marco, Filippo and Macchiavelli, Marco, (2016), *The Political Origin of Home Bias: The Case of Europe*, No 2016-060, Finance and Economics Discussion Series, Board of Governors of the Federal Reserve System (U.S.), <https://EconPapers.repec.org/RePEc:fip:fedgfe:2016-60>.
- (Marco and Macchiavelli, 2016) De Marco, Filippo and Macchiavelli, Marco, (2016), *The Political Origin of Home Bias: The Case of Europe*, No 2016-060, Finance and Economics Discussion Series, Board of Governors of the Federal Reserve System (U.S.)
- (Merler and Pisani-Ferry, 2012) Merler, Silvia and Pisani-Ferry, Jean, (2012), *Who's afraid of sovereign bonds?*, Policy Contributions, Bruegel, <https://EconPapers.repec.org/RePEc:bre:polcon:695>.
- (Muller and Bourque, 2017) Philippe Muller & Jérôme Bourque, 2017. "Methodology for Assigning Credit Ratings to Sovereigns," *Discussion Papers 17-7*, Bank of Canada.
- (Navaretti et al., 2016) Navaretti, Giorgio Barba and Calzolari, Giacomo and Pozzoli, Alberto Franco. 2016. Diabolic Loop or Incomplete Union? Sovereign and Banking Risk.
- (Neri 2013) Neri, Stefano, *The Impact of the Sovereign Debt Crisis on Bank Lending Rates in the Euro Area* (June 20, 2013). Bank of Italy Occasional Paper No. 170, Available at SSRN: <https://ssrn.com/abstract=2284804> or <http://dx.doi.org/10.2139/ssrn.2284804>

- (Oehler et al., 2007) Oehler A., Rumber M., Walker T., Wendt S. 2007 Are Investors Home Biased? Evidence from Germany. In: Gregoriou G.N. (eds) Diversification and Portfolio Management of Mutual Funds. Finance and Capital Markets Series. Palgrave Macmillan, London. [https://doi.org/10.1057/9780230626508\\_3](https://doi.org/10.1057/9780230626508_3)
- (Ongena et al, 2019) Ongena, Steven and Popov, Alexander and Van Horen, Neeltje. 2019. "The Invisible Hand of the Government: Moral Suasion during the European Sovereign Debt Crisis," American Economic Journal: Macroeconomics, American Economic Association, vol. 11(4), pages 346-379, October.
- (Pancaro et al, 2020) Pancaro, Cosimo and Żochowski, Dawid and Arnould, Guillaume, Bank Funding Costs and Solvency (January, 2020). ECB Working Paper No. 2356, Available at SSRN: <https://ssrn.com/abstract=3516058>
- (Popov and van Horen, 2013) Popov, Alexander and Van Horen, Neeltje, (2013), The impact of sovereign debt exposure on bank lending: Evidence from the European debt crisis, DNB Working Papers, Netherlands Central Bank, Research Department, <https://EconPapers.repec.org/RePEc:dnb:dnbwpp:382>.
- (Praet, 2013) Praet, Peter . 2013. The crisis response in the euro area. European Central bank. Available at <https://www.ecb.europa.eu/press/key/date/2013/html/sp130417.en.html>
- (Reinhart and Rogoff, 2008) Reinhart, Carmen & Rogoff, Kenneth. (2008). This Time is Different: A Panoramic View of Eight Centuries of Financial Crises. *Annals of Economics and Finance*. 15. 1065-1188. 10.3386/w13882.
- (Rossi, 2019) Rossi, Stefano. 2019. Sovereign debt restructuring and debt mutualisation in the euro area. Brussels: European Parliament. Retrieved from [http://publications.europa.eu/publication/manifestation\\_identifier/PUB\\_QA0419423ENN](http://publications.europa.eu/publication/manifestation_identifier/PUB_QA0419423ENN)
- (Williams, 2004) Williams, Jonathan. (2004). Determining management behaviour in European banking. *Journal of Banking & Finance*. 28. 2427-2460. 10.1016/j.jbankfin.2003.09.010.
- (Windmeijer, 2005) Windmeijer, Frank, (2005), A finite sample correction for the variance of linear efficient two-step GMM estimators, *Journal of Econometrics*, 126, issue 1, p. 25-51, <https://EconPapers.repec.org/RePEc:eee:econom:v:126:y:2005:i:1:p:25-51>.
- (Windmeijer, 2005) Windmeijer, Frank, (2005), A finite sample correction for the variance of linear efficient two-step GMM estimators, *Journal of Econometrics*, 126, issue 1, p. 25-51, <https://EconPapers.repec.org/RePEc:eee:econom:v:126:y:2005:i:1:p:25-51>.
- (Zoli, 2013) Zoli, Edda. 2013. Italian Sovereign Spreads: Their Determinants and Pass-Through to Bank Funding Costs and Lending Conditions. *IMF Working Papers*. 13. 10.5089/9781484357705.001.



# 3

## Essay 3

# **The Default Risk Capital Requirement: Credit Spreads vs Equity Prices Correlations**

## Synopsis

The third paper was motivated by a collaboration in Nordea. In Nordea I had the possibility to expand the way I analyzed banking risk. If in the two first papers the origin of the analysis was to understand what the bank risk drivers were. In this paper the analysis aims to understand whether the current regulation requisites could leave space for the banks to have underestimate their risk.

This paper looks at the FRTB (Fundamental Review of the Trading Book) which is an upcoming regulation expected to be implemented in Europe by 2025<sup>30</sup>. As previously indicated, occasionally the regulation presents flaws or gaps through which banks might underestimate their risk. Banks should be understood as social and organic institutions, as enterprises which find themselves in the middle of contradictory forces and who need to evolve and adapt to the regulation requirements, the market practices, the investors' expectations, and the customer's needs. Through one of these forces, the shareholders, banks are required to maximize value. At the same time, an opposite force exercised from the supervisor, exerts pressure on banks to limit their risk. The supervisors require banks to hold capital, however this has a cost which motivates the bank to try to minimize the capital requirements as much as possible.

In this scenario we find an upcoming regulation framework which defines loose guidance on the inputs needed to calculate the DRC (Default risk Capital). We find interesting to analyze if the space left by the regulation could be translated into an undesirable risk assumption. We analyze this flexibility in the regulation while keeping our focus in the calculation of DRC which is a component to capitalize market risk.

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<sup>30</sup> The European Banking Authority (EBA) has deferred the implementation date of the of final phase of Basel III reforms (revised market risk framework) to 2025. <https://www.ft.com/content/c872d5b9-984e-493c-942d-2dc9c8e4b7>

# THE DEFAULT RISK CAPITAL REQUIREMENT: CREDIT SPREADS VS EQUITY PRICES CORRELATIONS<sup>☆</sup>

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## Abstract

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The Fundamental Review of the Trading Book (FRTB) developed by the Basel Committee, aims to ensure a more resilient banking sector. This regulation, which will be implemented in Europe by 2025<sup>35</sup>, proposes the default risk capital (DRC) requirement to capture jump-to-default by reproducing the dependence between defaults of different obligors. To measure this default dependence, the regulation prescribes the use of a two-factor default simulation where the estimation of the correlations could either be based on credit spreads or on listed equity prices. In this work, we compare the correlation calibration process estimated from credit spreads and listed equity prices. We show that the source of data (credit spreads vs. listed equity prices) produces different estimations on the default correlation of obligors, presenting even opposite directions. A simulation proves that the number of expected defaults tend to be significantly higher when using equity weekly rates of returns than when bond weekly yields as a risk proxy. These discrepancies will translate into the DRC bank risk measurement. We aim that this work produces a better understanding of the suitability of each input for the implementation of this new regulatory requirement.

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*JEL classification:* G24; G23; G32

**Keywords:** Banking Regulation; Risk Modeling; Market Risk; Fundamental Review of the Trading Book; Default Risk Capital Requirement, Copula Model.

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<sup>35</sup> The European Banking Authority (EBA) has deferred the implementation date of the of final phase of Basel III reforms (revised market risk framework) to 2025. <https://www.ft.com/content/c872d5b9-984e-493c-942d-2dc9c8e4b7>

## 1. Introduction

The 26<sup>th</sup> of April 1986, the deputy chief engineer of the Chernobyl Nuclear Power Plant in Pripyat (Ukraine) was looking at the CDV-717 dosimeter after something went wrong. It was showing 3.6 Roentgens per Hour (r/hr). He reported this value was “not great but also not terrible”. He did not know at that time but, No. 4 reactor had collapsed, and the dosimeter was providing inaccurate low readings. As the science of radiation dosimetry developed, it was realized that the ionizing effect, and hence tissue damage, was linked to the energy absorbed, not just radiation exposure. Therefore, r/pr was no longer used as a measure of potential radiation damage. Crisis and shocks can be devastating although, they contribute to the development of science as far as we are able to learn from past mistakes.

Likewise, the unexpected Great Financial Crisis in 2008 revealed fragilities in the regulatory mechanisms of the financial system (Orphanides, 2010). For example, an underestimation of risk became evident as larger banks were lacking capital to absorb trading and credit losses (BSBS, 2013). The Basel Committee revised the market risk framework on the Fundamental Review of the Trading Book (BSBS, 2013)<sup>36</sup> to fulfil prior regulatory gaps. Among the changes of the new regulation, FRTB allows a two-factor default simulation model in the internal model approach for the calculation of the Default Risk Capital Requirement (DRC)<sup>37</sup>. FRTB also presents detailed specification on the empirical data sources to calibrate the model, which must be based either on credit spreads or on listed equity prices that cover a period of at least ten years (BSBS1; 2019).

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<sup>36</sup> The main areas subject to the review were: (i) the definition and limitation of the regulatory boundary between the trading book and banking book; (ii) the treatment of the credit-related products (this category includes the securitization and the non-securitization exposures in addition to the Credit Valuation Adjustments (CVA) charges); (iii) the approach of risk measuring for minimum capital requirements through two main reforms; stressed calibration and move from Value-at-Risk (VaR) to Expected Shortfall (ES) (BSBS, 2015).

<sup>37</sup> Captures default risk of credit and equity trading book exposures with no diversification effects.

As explained above, prior banking regulation has presented flaws that translated into underestimation of the banking risk exposure. Thus, the aim of this paper is to look at the potential flaws of upcoming regulatory changes. In particular, analyze the impact in the default risk capital calculation that emerge of using credit spreads or listed equity prices as obligor default predictors, both allowed data sources by the financial regulator. To this end, an empirical application of the FRTB regulation and more in particular, a small simulation within the DRC implementation, allows us to examine the differences in risk calculation when using equity prices versus credit spreads. We use a student-t copula where the two types of factors represent the region and industrial sector of the issuer. We focus on the calibration of the correlation structure and the number of degrees of freedom of the student-t distribution. The correlation is estimated using a Kendall's rank correlation technique, where the degrees of freedom are estimated using a maximum likelihood estimation (MLE) method. Through our analysis we can observe how the input used (credit vs equity) affects the results in the simulation. More specifically, we find that when equity is used as a risk proxy, the results are positively skewed (the range of the observations is larger in the right tale than in the left one). Additionally, we perform an impact analysis to verify how the volatility of the data used to calibrate the model can be translated into the default correlation matrix. To estimate the default correlation, we use two factors (i.e.: sector and region). We consider two data subsamples (with and without outliers), compute the factors for each of the subsamples and compare both results. This allows us to verify how the factors can react to outliers and hence show that instruments with differences in volatility could affect the factors and the correlation matrix.

The literature shows that equity and debt price dynamics can significantly differ from each other (Sangbae et al., 2005; Fama and French, 1993). The calculation of the regulatory capital of financial institutions needs to be closely monitored since financial innovations might result in capital arbitrage and the reduction of effective risk-based capital requirements (Jones, 2000). Laurent et al. (2015)

highlight the importance of a comparative analysis of the DRC implementation. They consider that their work is a first step towards a comparative analysis and calls for further works on the other components of the DRC modeling, as for example, the default probabilities. Thus, further analysis of DRC implementation method seems to be of interest for academics and regulators. We expect that the data source (i.e.: credit vs. equity) used to calibrate the model might impact the estimation on the default likelihood of the obligor. This paper builds upon previous asset pricing literature and its impact in bank risk measurement.

Overall, this work analyzes how disparities in the default correlations are caused by the source of data chosen in the calculation (i.e.: credit spreads vs. listed equity prices). We aim to prove that using the wrong data source could end in a risk miscalculation and thus leading to an incorrect bank capitalization. Our work aims to prevent regulators from possible credit risk model miscalibrations.

Our work may be of interest of financial regulators, as we empirically show that the selection of credit spreads versus equity volatility can affect the estimation of the default correlation matrix and by be translated into the DRC. We provide further empirical evidence on the open debate of the arbitrary selection of credit spreads versus equity prices, which can lead to an inaccurate bank capitalization and a risk underestimation with consequences for the solvency of financial institutions that would eventually affect the real economy by limiting the supply of credit to the private sector (Budnik et al. 2019).

The remainder of this paper proceeds in the following manner: in section 2 we focus on the Default Risk Capital (DRC) regulation and its implementation. We review the related literature in section 3. Then, in section 4, we provide the empirical analysis, followed, in section 5, by the discussion of the results. Finally, section 6 delivers the final conclusions on this work.



## 2. Default Risk Capital Requirement (DRC)

During a financial crisis or a market shock, capital reserves act as a buffer against bank losses, however during the Great Financial Crisis of 2008 those reserves were not sufficient. Several banking institutions and corporates failed which implied a large loss in the trading book<sup>38</sup> portfolio of banks. The prudential regulation failed to prevent the collapse of several financial institutions<sup>39</sup>. The reason for this risk underestimation can be found in Basel II accord. This regulation allowed banks to use their own Value-at-Risk (VaR) models to determine capital charges. VaR models underestimated the probability of extreme events during the late 1990s (BSBS, 2009). Another regulatory flaw that explains the losses faced by the banking institutions can be found in the lack of measurement credit risk in the trading book.

To solve the above-mentioned gaps, The Basel Committee on Banking Supervision published an updated regulatory directive, known as the Basel 2.5. This newly added directive supplemented the existing value-at-risk framework with the Incremental Risk Charge<sup>40</sup> also known as IRC (BSBS, 2019), a capital charge that captures default and migration risk, at the same time, under Basel 2.5 banks started measuring the credit risk in the banks trading book.

After the publication of Basel 2.5. and with the purpose of understanding prior regulatory errors and to amend existing regulations, The Basel Committee on Banking Supervision published The Fundamental review of the trading book: A revised market risk framework (BSBS, 2013)<sup>41</sup>. One of the

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<sup>38</sup> The banks positions are usually classified in two categories: the banking book and the trading book. The first one is constituted mostly by standard credit products (namely loans and mortgages). The second one, trading book, comprise structured financial instruments as stocks, bonds, and other types of derivatives. (Bonollo et al, 2018).

<sup>39</sup> Bear Stearns was acquired by JPMorgan Chase (JPMC) in a transaction assisted by the Federal Reserve Bank of New York (FRBNY). Lehman Brothers filed for bankruptcy. Citigroup and Bank of America sought specific support programs protecting against losses. Weinberg (2013).

<sup>40</sup> The incremental risk charge (IRC) is a regulatory requirement from the Basel Committee. It complements the existing Value-at-Risk (VaR) and captures the loss due to default and migration events at a 99.9% confidence level over a one-year capital horizon.

<sup>41</sup> The main areas subject to the review were: (i) the definition and limitation of the regulatory boundary between the trading book and banking book; (ii) the treatment of the credit-related products (this category includes the securitization and the non-securitization exposures in addition to the Credit Valuation Adjustments (CVA) charges); (iii) the approach of risk measuring for minimum capital requirements through two main reforms; stressed calibration and move from Value-at-Risk (VaR) to Expected Shortfall (ES) (BSBS, 2015).

regulatory changes is dedicated to the Default Risk Capital Requirement (DRC), which intends to substitute the Incremental Risk Charge (IRC) and capture jump-to-default (JTD) risk by credit spread shocks under the sensitivities-based method. The DRC is a measure that aims to capture the default of credit and equity trading book exposures not considering diversification effects (allowed in other market risks). DRC due to its nature intends to capture the stress in the tail risk of the default distribution (Wilkins & Predescu, 2017). In contrast to the previous IRC measure, the DRC does not contemplate other diversification effects that are allowed within other market risks- the purpose of this is to reduce the variability that IRC could be subject to. Since the publication of Basel 2.5 The Basel Committee on Banking Supervision has been working to amend and improve existing regulations by changing the IRC into a default risk capital model<sup>42</sup> which establishes the usage of a two-factor simulation model removing the possibility for the banks to choose single-factor or a multi-factor default risk model. Other differences that have a practical impact is that the DRC limits the recognition of hedging possibilities<sup>43</sup>.

The DRC does not only measure the risk of the losses due to an obligor's default but also the potential indirect losses that arise from a default. For this reason, to calculate the DRC capital requirement there are four components that need to be calibrated and modelled; The first component is the obligor's correlation, the second one is the Probability of Default<sup>44</sup>, the third component is the Loss Given Default and the last component is the Jump to Default model.

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<sup>42</sup> The default risk capital (DRC) requirement is intended to capture jump-to-default (JTD). Following the BIS definition jump-to-default risk is the risk that a financial product, whose value directly depends on the credit quality of one or more entities, may experience sudden price changes due to an unexpected default of one of these entities (BSBS4, 2015).

<sup>43</sup> Only hedging relationship between net long and net short positions within the same obligor are recognized. No hedging is recognized between distinct obligors

<sup>44</sup> For the regulator the default risk is considered as the direct or indirect loss arising from the obligor's default (BSBS, 2009).

For a better understanding of DRC Bonollo et al, (2018) explain how credit risk can be subdivided in two areas; the first one identifies with the definition of default models for each counterparty, along with the estimation of related default probabilities. The second one, related to portfolio credit risk intends to optimize the individual measurement of a debtor's risk measurement within the portfolio.

When a bank applies for the internal model approval to calculate the capital of its trading desk (for traded equity and credit), it needs to follow the DRC requirements (BSBS, 2019). As mentioned in the introduction, DRC needs to be based on credit spreads or on listed equity prices. The regulation<sup>45</sup> states that banks must have clear policies and procedures that describe the correlation calibration process, documenting in which cases they use credit spreads or equity returns.

In this paper we use the DRC upcoming regulation to compare the impact in the risk calculations of using credit or equity data. DRC has been incorporated to protect banks from credit risk related to illiquid products whose risk is not reflected in VaR. Under FRTB (BSBS 2012, 2013, 2015) it is prescribed the use of a two-factor default simulation model in the internal model approach for DRC.

The implementation DRC requires: (i) default correlations that cover a period of at least 10 years, (ii) a time horizon that includes a period of stress, (iii) a one-year based liquidity horizon, (iv) to recognize the impact of correlations between defaults and among obligors, including the effect on correlations of periods of stress. Banks must further validate their modelling approach, including the choice and weights of its systematic risk factors. Data sources to calibrate the model must be either the equity prices or credit spreads (BSBS<sub>1</sub>; 2019).

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45 (Bank for International Settlements, 2019) MAR33- Internal model approach: capital requirements calculation

### 3. Related Literature

As covered in the prior section during the Great Financial Crisis of 2008 banks reserves were not sufficient as a buffer against bank losses. New regulatory requirement was put in place to capture jump-to-default, which is the risk that a financial product, whose value directly depends on the credit quality of one or more entities, may experience sudden price changes due to an unexpected default of one of these entities (BSBS4, 2015).

DRC calculation is defined in the regulation, but it might present limitations related to the data or methodology used for its computation. We aim to analyse these sources of discrepancies in this paper. In particular, in our work we build upon Laurent et al. (2015), who identified a source of variability in the correlation matrices when equity or credit inputs were applied, and empirically test how these sources might affect the results of the correlation calibration. We aim to identify how the arbitrary selection of credit or equity data may affect the calibration of the default correlation structure of DRC and provide different risk assessments, leading to risk under or overestimation. In this section we provide related literature and our research hypothesis on this matter.

As indicated in the prior section, one of the Basel II objectives was to address the trading book risk. During the financial crisis, most losses in banks trading books were significantly higher than the minimum capital requirements<sup>46</sup>. Banks are required to capitalize market risk<sup>47</sup> to face potential losses, and the required amount of capital can be determined either by a standardized methodology provided by the regulator (the so-called *Standardized Approach*) or via an internal model (created by the bank and approved by the regulator).

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<sup>46</sup> Under the former Pillar 1 market risk rules

<sup>47</sup> Market risk can be defined as the risk of losses for a position or portfolio as a consequence of the change in the level of one or more macroeconomic factors, such as market prices, rates, indices, implied volatilities, correlations or other market liquidity factors (SEC, 2014).

As a response, the Basel Committee on Banking Supervision complemented the existing value-at-risk framework with an incremental risk capital charge<sup>48</sup> also known as IRC (BSBS, 2019). In the package measures introduced as part of the “Basel II.5”, the Committee initiated a fundamental review of the trading book regime, beginning with an assessment of “what went wrong”. This generated a review of the trading book regiment which ended up in the Fundamental review of the trading book: A revised market risk framework (BSBS, 2013); also known as FRTB.

Wilkins & Predescu (2017) present the first modelling framework for the DRC measure. The authors consider relevant a further study of the application of the FRTB regulation as the banking industry needs to prepare for this change. Laurent et al. (2015) analyze the theoretical foundations and relevance of the Basel review for the Trading book and credit risk measurement.

The purpose of the DRC model is to capture the dependence in the changes in credit spreads related to traded credit instruments. As it will explained in more detailed in the section “Model description”, the DRC is constructed through regression analysis of standardized company returns against the two selected factors returns.

The relationship between of bonds and equity volatility may not remain stable and can differ across countries and time periods (Sangbae et Francis; 2005). Across the literature, several authors study the behavior, effects and differences between equity volatility and bond spread (i.e.: Campbell & Taksler, 2003; Yongjun and Yan, 2008; and Mitchell, 2017). Campbell & Taksler, (2003) show how in the late 1990s, US stocks and corporate bond markets did not display an intuitive behavior relative to each other as a strong rise in stock prices used to be followed by rises in bond yields, thus showing that the optimism of the equity market was not shared by bond investors. Similarly, Yongjun and Yan (2008)

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<sup>48</sup> The Committee therefore requires banks to calculate a stressed value-at-risk considering a one-year observation period relating to significant losses, which must be calculated in addition to the value-at-risk based on the most recent one-year observation period. The additional stressed value-at-risk requirement will also help reduce the procyclicality of the minimum capital requirements for market risk.

show that this relationship between equity and credit spread can change during economic cycles. Moreover, during economic expansions, those firms with high cash flow betas display a lower credit spread than those with low cash flow betas and this relationship seem to reverse in economic recessions. More recently, Fan and Mitchell (2017) show that despite the equity-bond correlation has been negative since the early 2000s nothing can state this correlation to endure. When the authors examine data from 1870s, they find that the equity-bond correlation is highly dynamic finding prolonged periods of positive correlation.

The relationship between stock prices and bonds spreads fluctuates across time. This can be explained as the returns of the two assets are driven by different factors. Campbell and Ammer (1993) show that the low correlation between excess stock and bond returns arises from the factors that determine their prices. For instance, stock prices are mostly driven by the expectations on future stock returns, while bond returns are affected primarily by expected inflation rates. In the same vein, Fama and French (1993) state that while stock-market prices are more related to overall market prices. The firm size and book-to-market equity, bond prices are more influenced by maturity and default risk.

Another strand of literature looks at disparities between equity and credit data. Guo (2007) states that there is no evidence of a positive risk-return trade-off in the relationship between expected stock market volatility and returns; a rise in the expected stock volatility carries a raise in the expected equity premium, which should have made risk averse investors to move to more conservative positions in Treasury bills reducing the equity prices. Likewise, Norden & Weber (2009) show that stock returns may lead to changes in CDS and bonds spreads, they verify the existence of a negative relationship between stock returns and CDS/bond spreads changes. They further find that the changes in bond spreads are more strongly lagged to stock returns the larger the size of bond issues.

Marsh & Wagner, (2012) and Blanco et al (2005) look at how equity and bond prices react to market information. Marsh & Wagner, (2012) show that equity returns lead CDS returns, with the CDS respond to positive news being delayed. Similarly, Blanco et al (2005) state corporate bonds response to market information to be slower than that of CDS and, by extension, equity prices.

Lastly, another source of differences between equity prices and credit spreads relies in information availability. While equity prices are only available for public listed corporations, credit prices and spreads are also available for private companies and governments institutions. This can affect the calculations as by using credit spreads some private or governmental issuers could be included into the calculation of factors and the default correlation matrix.

The above-described literature might partly explain why equity and credit instrument prices and spreads might have a different behavior and relationship across time. Given these differences, the data selection could lead financial institutions to take arbitrary choices regarding the calibration of the default correlation structure and defaulting the comparison among institutions (Laurent et al, 2015).

Hence, we expect that credit spreads or listed equity prices used in the calculation default risk capital requirement are not substitutes and the selection of one of other as a model input can affect the calculation of correlation calibration process, amplifying the effect of model error with the subsequent incorrect bank capitalization. Thus, we hypothesize:

*H1: Different sources (credit spreads vs. listed equity prices) produce different calculations on the correlation calibration process of the default risk capital requirement.*

#### **4. Empirical Analysis**

In this section, we empirically test the DRC. To that end, we follow the Internal Model Approach (IMA) applicability under FRTB. The Article 104 of the Capital Requirements Regulation (CRR) establishes that

institutions that follow this approach must have clearly defined guidelines and procedures in place to determine which positions are included in the trading book<sup>49</sup>. Additionally, DRC stipulates that the internal model can only include the products subject to default risk (i.e.: non-securitization portfolios, non-correlation trading portfolio, or non-CTP, and correlation trading portfolio, or CTP) (BIS, 2016).

#### **4.1 Sample Selection**

To implement the simulation of the DRC, this study uses market data on credit spreads and equity quotients from different issuers. We classify our issuers using the Bloomberg Industry Classification Systems (BICS) in the different categories. The securities data issuers are selected from a financial information and services database. In the case of equity, we have used public prices from Yahoo Finance while in the case of credit, our source of data is the Markit database<sup>50</sup>. The data set contains 206 credit issuers based on data availability from Yahoo Finance and Markit database and covers a period from January 2008 to December 2020<sup>51</sup>.

Our selected issuers are divided per sectors and regions as it is reflected in Table 1. Based in the country of origin the issues are classified into regions Europe, North America (*N.America*) and World (when they do not belong to previous categories). The sectors included *are Basic Materials, Consumer Goods,*

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<sup>49</sup> Determined by the Article 4(1)(86) of the CRR, the “trading book” consists of “all positions in financial instruments and commodities held by an institution either with trading intent, or to hedge positions held with trading intent. Between others: (i) instruments in the correlation trading portfolio, (ii) instruments resulting from securities underwriting commitments, (iii) instruments held as accounting trading assets or liabilities (“held for trading” assets and liabilities), (iv) instruments resulting from market-making activities, listed equities (other than equity investment funds), (v) trading-related repo-style transactions (repo-style transactions that are entered into for liquidity management purposes and are valued at accrual for accounting purposes, are not presumed to be trading-related), (vi) instruments that would give rise to net short risk positions for equity risk or credit risk in the banking book, and options including bifurcated embedded derivatives from instruments issued out of the banking book that relate to credit or equity risk.

While the banking book consist of unlisted equities, instruments designated for securitization warehousing, real estate holdings, retail credit and credit to small and medium-sized enterprises (SMEs), other types of credit, equity investments in a fund for which the institution cannot obtain liquid prices, derivative instruments and instruments held for the purpose of hedging.

<sup>50</sup> Markit is a leading provider of critical financial market data and information services

<sup>51</sup> The period selected with the purpose to cover a period of at least ten years and a period of stress as stated in the regulation (BSBS1; 2019).

*Consumer Services, Energy, Financials, Healthcare, Industrials, Technology, Telecommunications and Utilities*

#### **4.2 Variables**

DRC aims to capture default risk capital charge of the trading book. The default correlation model prescribes banks the usage of credit spreads or listed equity prices to calibrate the default correlations. (BSBS, 2012, 2013) and two types of systematic factors to compute the correlation between defaults of different obligors. Following Laurent et al. (2015) and Wilkens & Predescu (2017), we chose the factors *Region* and *Sector*. We cover the period 2008 to 2020 that covers as the stress period the Great Financial Crisis.

#### **4.3 Selection of the dependent variable**

Our purpose is to compare the results of using credit spread or equity prices, consequently we use the data on equity prices and credit spreads on different issuers. Regarding debt, we consider the daily credit spreads with a maturity of 5 years calculated from CDS quotes from different sources. As it can be read in the sample selection, the data set contains 206 credit issuers based on data availability from Yahoo Finance and Markit database and covers a period from January 2008 to December 2020<sup>52</sup>. To ensure that times series correspond to liquid issuers and thus are representative of credit quality of the issuers rather than market frictions, for each observation, only issuers that have at least a composite depth greater or equal to 3 in at least one out of the last seven days are considered. Moreover, to reduce the noise present in the daily credit spreads time series, weekly observations are used from January 2008 to December 2020 (i.e., the most recent 12 years of observed data). With regards equity, we consider the weekly quotients of the listed names selected from the credit spread selection. Aligned with credit data, we have a total of 206 issuers, and we cover the same time span.

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<sup>52</sup> The period selected with the purpose to cover a period of at least ten years and a period of stress as stated in the regulation (BSBS1; 2019).

An existing difference between the two samples lies in the fact that credit spread data can capture the public sector not available for the equity data.

*Table 1 Equity and Credit issuers sector and region distribution*

<b>Row Labels</b>	<b>Europe</b>	<b>N.Amer</b>	<b>World</b>	<b>Total</b>
Basic Materials	5	8	7	20
Consumer Goods	6	12	3	21
Consumer Services	7	9	3	19
Energy	9	9	7	25
Financials	18	3	15	36
Healthcare	4	9	2	15
Industrials	15	3	1	19
Technology	3	4	1	8
Telecommunications	15	1	6	22
Utilities	10	2	9	21
<b>Total</b>	<b>66</b>	<b>60</b>	<b>54</b>	<b>206</b>

#### **4.4 Factors Selection**

As defined in the regulation, banks using the internal model approach to calculate DRC must apply a two-factor default simulation model (BSBS, 2013). Following Laurent et al. (2015) and Wilkens & Predescu (2017), we select as risk factors the region and industry of each issuer.

The Sector as an aggregation of in industry-specific characteristics can also be an explanatory factor of Systematic risk. Despite the dynamics of industry-specific factors within a sector can vary between sectors, these are more pronounced for the transportation and energy, consumer goods, and retail and distribution industries (Schwaab et al., 2016). For the different issuers, the sector is extracted from the Bloomberg Industry Classification Systems (BICS) which is a hierarchical classification based on business activities. In our analysis we only use the primary industry sector classification, including *Communications*, *Consumer Goods (ConsGood)*, *Consumer Services (ConsServ)*, *Energy*, *Financials*, *Health care*, *Industrials*, *Materials*, *Technology* and *Utilities* (Clemente et al., 2014).

The *Region* factor corresponds to the main location of the issuer. We identify three regions:

*Europe, N. America, and World. World* comprises all the remaining continents and regions not covered in previous categories (i.e.: Asia, Oceania, East Europe, Africa, Supra, Offshore, Lat. America, Middle East, India, and Caribbean).

#### **4.5 Model description**

The purpose of the credit spread factor copula model is to capture the dependence related to credit spreads and equity prices. The copula models enjoy an increasing popularity in finance. This model can be found in the literature to study the asymmetric dependences between financial products where Gaussian and Student-t copula are most of the models used (Fischer et al 2009). Li (2000) firstly introduced the Gaussian copula model to the credit field. There are different types of copula models being the factor copula models the most often, being the factor model the most used in the literature (Hull and White, 2004; Errais et al. (2007), Cont and Minca (2008), Giesecke and Kim (2007), and Longstaff and Rajan (2008)) due to the time consuming are due to its computational requirements. In the literature there are critics to the Gaussian copula approach arguing that it lacks tail dependence. Is with the purpose to overcome this, that the DRC regulation prescribes that calibration of the parameters in the model should cover a period larger 10 years, including a period of stress. Additionally, another argumentation in favor of the suitability of the Copula model for DRC is presented by Slime (2018) who explains that as trading portfolios are not unidirectional the tails of the loss distribution are not per say matching the tails in the Gaussian copula.

It has been designed to be used for DRC. Hence, the model in order to be compliant with regulatory requirements prescribes the use of two types of systematic factors, it is assumed:

$$X = \mathbf{BZ} + \varepsilon (I)$$

were

1.  $X = (X_1, X_2, \dots, X_d)$ ,  $d \in N$ ,  $X_i$  being the asset return of obligor  $i$  and  $d$  the number of obligors in the DRC portfolio.
2.  $Z = (Z^{global}, Z_1^{region}, Z_2^{region}, \dots, Z_{p_1}^{region}, Z_1^{industry}, Z_2^{industry}, \dots, Z_{p_2}^{industry})^t$  is a random vector of systematic factors, where the chosen types are region and industrial sector and  $p = p_1 + p_2 + 1 < d$ . A global factor common to all obligors is also introduced. The joint distribution of the factors is specified through a student-t copula, as it will be described more in details later.
3.  $\varepsilon = (\varepsilon_1, \varepsilon_2, \dots, \varepsilon_d)$  is a random vector of idiosyncratic error terms, which are uncorrelated and have mean 0. As for the systematic factors, a student-t copula is used to define the joint distribution of the idiosyncratic factors.
4.  $\mathbf{B} \in \mathbb{R}^{d \times p}$  is a matrix of constant factor loadings.
5.  $\text{Cov}(Z, \varepsilon) = E((\mathbf{Z} - E(\mathbf{Z})) \varepsilon^t) = 0$ .

Using the above factor model allows us to explain the dependence and randomness in the components of a  $d$ -dimensional vector  $X$  in terms of a smaller set of common risk factors  $Z$ . The systematic risk  $Z$  is usually dominating, whereas the risk in the error terms, in other words the idiosyncratic risk, is partly mitigated by a diversification effect.

The joint distribution of the factors is defined via a copula model. In the specific, the vectors  $Z_1, Z_2, \dots, Z_p$  have identical distribution function  $F_Z$ , and their copula  $C(Z_1, Z_2, \dots, Z_p) = (F_Z(Z_1), F_Z(Z_2), \dots, F_Z(Z_p))$  that is the distribution of  $(F_Z(Z_1), F_Z(Z_2), \dots, F_Z(Z_p))$  follows a student-t.

Copula have become popular tools among practitioners for modelling the joint distribution of financial variables, see for example Li (2000) and Meucci et al., (2007). An advantage of the copula technique compared to other modelling approaches is that it easily allows to describe the dependency between random variables independently on their marginal distribution, thus providing greater flexibility. For an overview on the subject, we refer to Brigo, Pallavicini and Torresetti (2010).

Our model is in line with the one applied in Wilkens & Predescu (2017), to which we refer to for more details. Different approaches are possible, such as the one proposed by Laurent et al. (2015) where the empirical correlation between the issuers is narrowed to the nearest correlation matrix with a reduced number of factors chosen a priori. However, a disadvantage of this model over the one considered in this paper is the interpretation of the factors to which is not easy to attribute an economic meaning. On the contrary, the use of industry and region factors is easier to understand as these are observable characteristics of the issuers.

To avoid multi-collinearity between the factors, a regression of the industry and region factors on the common global factor is performed, which allows to write:

$$Z_{t,j} = \beta_j Z_{t,0} + \tilde{Z}_{t,j} \quad j = 1, 2, \dots, p$$

Where  $\tilde{Z}_{t,j}$  are the factor residuals. We can therefore rewrite (1) as:

$$\mathbf{X} = \tilde{\mathbf{B}}\tilde{\mathbf{Z}} + \boldsymbol{\varepsilon}$$

At this point, we work with the factor residuals, rather than the residuals themselves. However, for ease of notations, we will denote the factor residuals by  $Z_{t,j}$  rather than  $\tilde{Z}_{t,j}$ .

### *Model calibration*

One of the main objectives of this paper is to compare the calibration obtained from our model by using equity prices versus credit spreads.

The degrees of freedom of the student-t copula are estimated via a semi-parametric maximum likelihood approach. This approach allows us to distinguish between the copula parameters and the nuisance parameters, the latter being treated non-parametrically via the empirical cumulative distribution. The approach can thus be considered as a hybrid between the parametric and the nonparametric approach. We refer to Genest et al (1995) for more details on the subject. The correlation matrix of the factors is estimated via a Kendall Tau estimation technique, which has the advantage of being dependent on the copula only and not on the marginal distribution of the variables.

## **5. Results and discussion**

In this paper we undertake a comparison analysis of the two first components of the DRC model: we calculate the obligor's correlation, the second one is the Probability of Default. The purpose is to analyze how the different data selection affects to the correlation between issues and subsequently to the probability of default.

### ***5.1 Impact of outliers in Factors calculation***

To measure the correlation matrix of the risk factor Student-t copula using the Kendall's Tau. Across the literature we find that Kendall's Tau is used for calculation of default correlation and volatility correlation (El Ouadghiri et al, 2016, Luciano, 2005), this can be explained due to the stability of this methodology and its robustness as an estimator for correlations (Tchernitser & Rubisov, 2009). However, in our model to capture the dependence between the issuers sectors and regions (using credit spreads or equity data as risk proxies) we firstly assign all issuers to observable risk factors (region, sector and a common factor referred to as global). This implies that we calculate the correlation between the factors. For this reason, we first undertake an analysis of the sensitivity of the factors to outliers in the credit spreads or quotients. Our purpose is to find if those prices with higher volatility could affect the factors and translate afterwards to the correlation. This first step would help

us to later understand and explain the impact of credit spread and equity price volatility on the correlations.

To analyze the factor sensitivity, we obtain a subsample for which we compare the factors output with and without outliers<sup>53</sup>. By removing the outliers, we improve the data analysis as otherwise the distribution is skewed in the direction of the outliers (Wu et al, 2009; Golmohammadi et al, 2015).

In our subsample, we select the components of the following indexes: Nasdaq100, Dow Jones 30 and OMX25 and STOXX 50. We cover the period 2008 to 2019. Additionally, we make three assumptions. First, as some companies can belong to more than one index, and to avoid sectors or regions misrepresentation we only consider the company names one time. Second, as stock indexes can modify their composition across time, we maintain a static and comparable sample. We fix the index components by May 2020. Because of fixing the different index components we encounter companies in our sample that can have missing quotients in prior years as they were publicly traded at that time. The third assumption is regarding the volatility of equity prices as we remove all quotients reflecting a volatility higher than 20% in a day. This is in line with the stock exchanges rules to handle “Circuit breakers”<sup>54</sup> in which a stock with a volatility of 20% is halted until the day after.

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<sup>53</sup> We understand outliers as these observations which are outside the interval Average  $\pm$  3 Standard deviation.

<sup>54</sup> [https://www.nyse.com/publicdocs/nyse/NYSE\\_MWCB\\_FAQ.pdf](https://www.nyse.com/publicdocs/nyse/NYSE_MWCB_FAQ.pdf) and <https://www.nasdaqtrader.com/trader.aspx?id=CircuitBreaker>

Figure 1 Equity Factors with Outliers

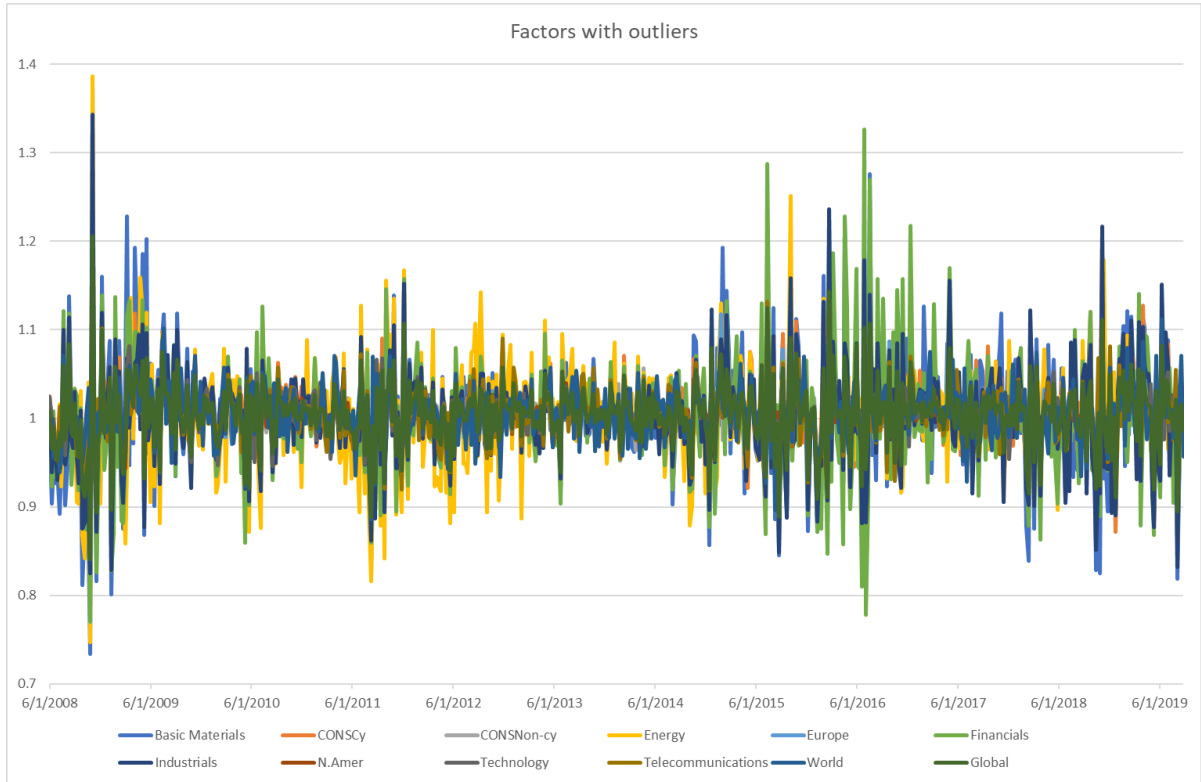
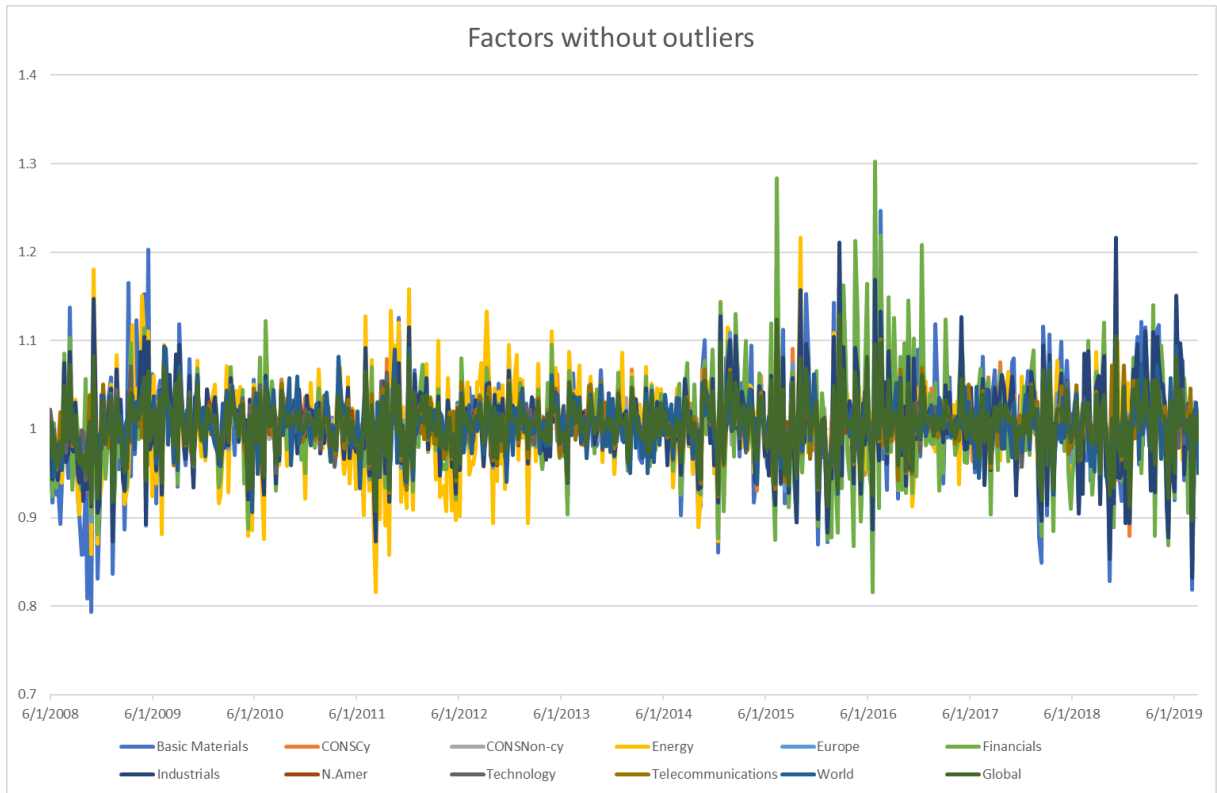


Figure 2 Equity Factors without Outliers



By comparing the factors with and without outliers we can test if the outliers exert a significant effect on the factor values. As expected, the range of the factors narrows when we remove the outliers. This

is observable mainly during the year 2008 as can be noted from the figure. Also, by removing the outliers the larger differences are observed in 2008 but also in 2016. The sectors which seem to be more affected by the outliers are *Energy, Industrial, Financials* and *Global*. A higher volatility in prices can directly affect the value of the factors on the correlation estimation. Thus, differences in the volatilities of credit and equity values could lead to differences in the correlations.

## 5.2 Factors

The systematic factors, common to all users, are constructed out of observable data in the form of changes on equity prices and credit spreads. In tables 2 and 3 we provide the summary of statistics for equity and credit data respectively. In a quick overview we can observe that there are significant discrepancies between the average factor values. In general, the equity average values are negative while the credit spreads ones are positive. Looking at the standard deviation, we observe, in general, credit spread data to be more disperse. Given that we consider bonds with different ratings in our analysis, the results are aligned with Norden and Weber (2009).

*Table 2* Summary statistics of the rating risk factors weekly Equity prices.

	Mean	Std	Min	Median	Max
Equity Basic Materials	-0.002	0.009	-0.056	-0.001	0.026
Equity Consumer Goods	0.000	0.011	-0.071	0.001	0.062
Equity Consumer Services	0.000	0.011	-0.069	0.000	0.065
Equity Energy	-0.002	0.012	-0.080	-0.001	0.065
Equity Europe	-0.001	0.010	-0.057	0.000	0.036
Equity Financials	-0.002	0.013	-0.082	-0.001	0.075
Equity Healthcare	0.000	0.008	-0.054	0.001	0.032
Equity Industrials	-0.002	0.013	-0.071	-0.001	0.062
Equity N.America	0.000	0.010	-0.064	0.000	0.050
Equity Oil & Gas	-0.002	0.013	-0.069	-0.001	0.069
Equity Technology	0.000	0.009	-0.041	0.000	0.037
Equity Telecommunications	0.000	0.008	-0.045	0.000	0.024
Equity Utilities	-0.001	0.006	-0.045	-0.001	0.014
Equity World	-0.001	0.007	-0.042	-0.001	0.022
Equity Global	-0.001	0.007	-0.054	0.000	0.034

Table 3 Summary statistics of the rating risk factors weekly Credit Spread returns.

	Mean	Std	Min	Median	Max
Credit Consumer Goods	0.002	0.017	-0.148	0.001	0.125
Credit Consumer Services	0.002	0.020	-0.115	0.002	0.097
Credit Energy	0.000	0.011	-0.049	0.001	0.058
Credit Europe	0.006	0.012	-0.065	0.006	0.050
Credit Financials	0.014	0.019	-0.066	0.014	0.083
Credit Government	0.000	0.020	-0.179	0.000	0.105
Credit Healthcare	0.000	0.008	-0.038	0.000	0.055
Credit Industrials	0.001	0.010	-0.063	0.001	0.043
Credit Materials	0.001	0.012	-0.082	0.001	0.051
Credit N.America	0.001	0.012	-0.066	0.001	0.061
Credit Technology	0.001	0.010	-0.047	0.001	0.046
Credit Telecommunications	0.001	0.012	-0.097	0.001	0.064
Credit Utilities	0.001	0.009	-0.045	0.001	0.045
Credit World	0.001	0.010	-0.079	0.001	0.055
Credit Global	0.003	0.010	-0.051	0.004	0.045

In figures 3 and 4 we present the evolution across time of the factors for the different regions and sectors. Equity factors (figure 3) seem to have flatter levels while the credit spreads (figure 4) present a more pronounced downtrend. Nevertheless, factors generated with both data share the same relative higher levels. In figure 3 we can observe that volatility factors reach relatively high levels in 2008, 2012, 2013 and 2015. The minimum levels take place in 2008 and in 2012. The Industrial sector presents the largest volatility moving in an interval between 0.07 and -0.057. While the Global sector exhibit the lowest volatility. Regarding regions, North America (*N.Amer*) is the most volatile, in contrast, Europe is the region with the lowest volatility.

Figure 3 Equity Factors

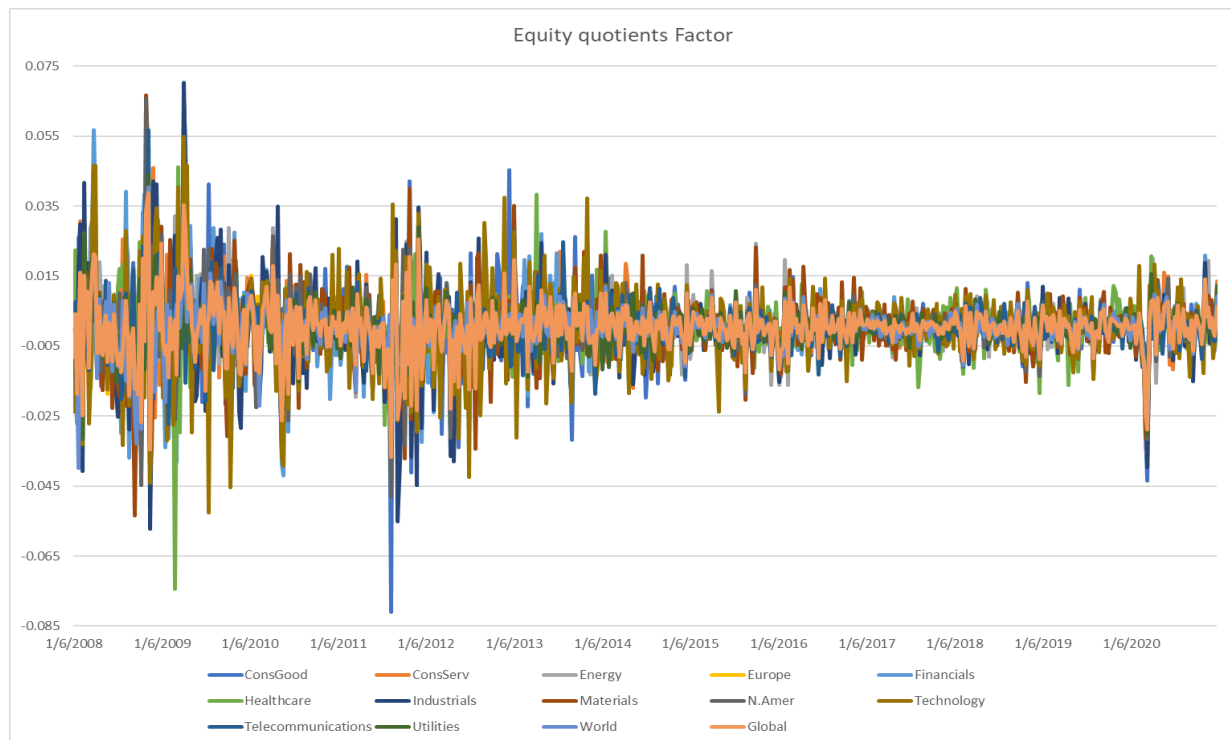
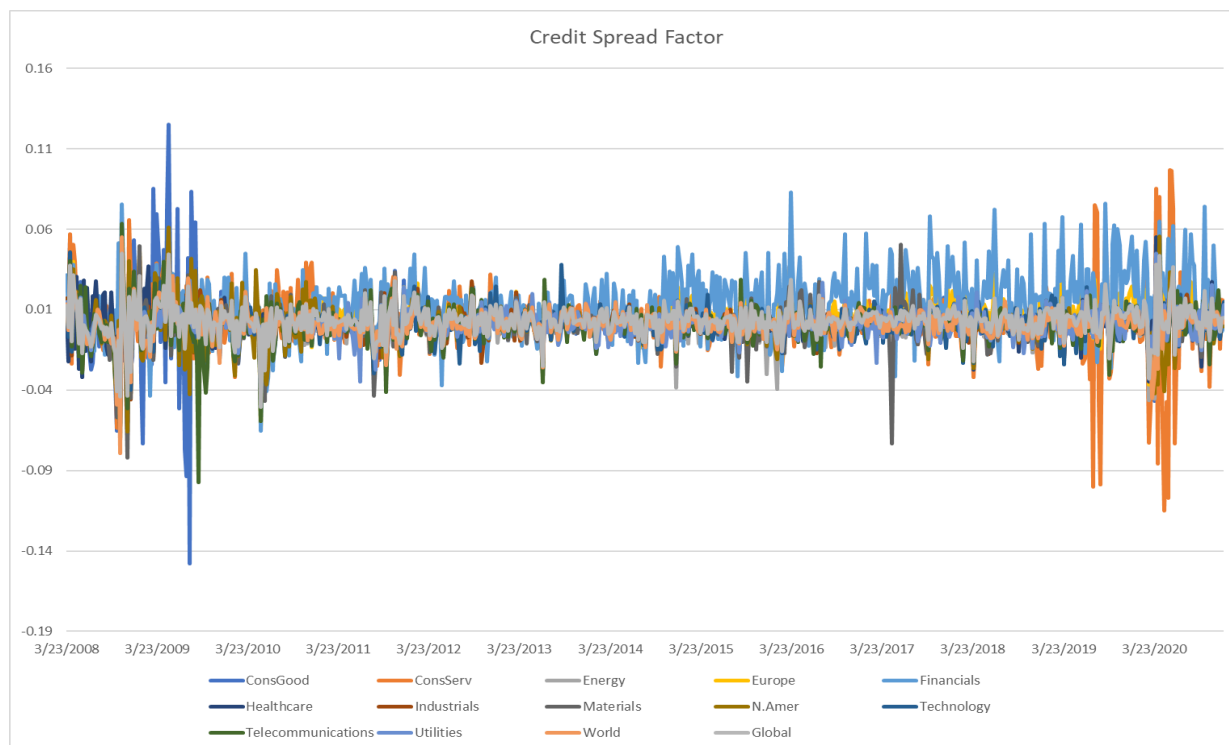


Figure 4 shows credit spread factors. We can identify three main picks (2009, 2016 and 2020) with an overall decreasing trend. As can be noted from the figure, credit factors present a lower volatility from equity factors, which is supported by the literature (Reilly et al, 2000). Moreover, credit spreads for *ConsGoods* seem to have been widely stressed in 2008 which could be related to the effects of consumption-reducing forces during the Great Recession (Petev et al, 2012). A similar trend is observed in the 2020 by the *ConsServ* highlighting the drastic impact from Coronavirus on service organizations. Finally, the financial sector shows an appreciable higher volatility for the whole timespan.

Figure 4 Credit Spread Factors



### 5.3 Correlation matrices

In Table 4 we present the pairwise correlations on equity prices between regions and sectors. In general, the correlation between sectors tends to be lower than the correlation between regions. The correlation distribution seems to be on average low (0.022). *Europe* and *N.Amer* present the largest negative correlation between regions (-0.70), followed by *World* and *Europe* (-0.51). *Global* and *Industrials* show a highly negative correlation (-0.83); likewise *N.Amer* and *ConsServ* present the largest positive correlation between a region and a sector (0.72). Finally, *Technology* and *Industrials* (0.57) and *Healthcare* and *ConsServ* (0.46) seem to be highly positively correlated sectors.

Table 4 Correlation Matrix on equity prices

Factor	Consgood	Consserv	Energy	Financials	Healthcare	Industrials	Materials	Technology	Telecommu nications	Utilities	Europe	N.Amer	Global	World
Consgood	1													
Consserv	-0.24	1												
Energy	-0.06	0.07	1											
Financials	-0.11	-0.27	-0.09	1										
Healthcare	-0.16	0.46	-0.15	-0.37	1									
Industrials	-0.03	0.09	0.18	0.03	0.31	1								
Materials	-0.45	-0.07	-0.05	-0.07	0.00	-0.16	1							
Technology	0.25	-0.11	0.12	0.06	0.16	0.57	-0.10	1						
Telecommu nications	-0.11	-0.04	-0.37	0.01	-0.01	0.15	-0.26	0.13	1					
Utilities	-0.32	0.27	-0.01	0.00	0.04	-0.38	0.35	-0.30	-0.32	1				
Europe	0.35	-0.44	0.06	-0.08	-0.07	0.29	-0.23	0.29	0.16	-0.57	1			
N.Amer	-0.15	0.72	-0.08	-0.40	0.40	-0.08	0.05	-0.28	-0.02	0.25	-0.70	1		
Global	-0.02	-0.25	-0.25	0.14	-0.46	-0.83	0.02	-0.64	-0.13	0.19	-0.15	-0.08	1	
World	-0.25	-0.28	-0.03	0.57	-0.29	-0.26	0.36	-0.06	-0.20	0.54	-0.51	-0.22	0.17	1

In table 5, we present credit spread correlations. As can be noted from the table, the overall correlation levels are lower than those provided by equity prices. Like table 4, *Europe* and *N. Amer* (-0.62) present the largest negative correlation between regions followed by *World* and *Europe* (-0.54). *N. America* and *Conservare* also present a positive correlation, but the coefficient (0.49) is significantly lower than the one provided in equity prices.

Table 5 Correlation Matrix on credit spreads

FACTOR	ConsGood	ConsServ	Energy	Financials	Government	Healthcare	Industrials	Materials	Technology	Telecommunications	Utilities	Europe	N.Amer	Global	World
ConsGood	1														
ConsServ	0.00	1													
Energy	0.05	0.12	1												
Financials	-0.44	-0.43	-0.37	1											
Government	-0.03	-0.10	0.16	-0.15	1										
Healthcare	0.05	-0.07	0.09	-0.18	-0.03	1									
Industrials	0.09	0.03	0.31	-0.45	0.10	0.10	1								
Materials	0.13	0.04	0.17	-0.47	0.00	0.06	0.40	1							
Technology	-0.07	0.04	0.26	-0.34	0.06	0.02	0.29	0.21	1						
Telecommunications	0.09	0.05	0.26	-0.43	0.08	0.12	0.23	0.14	0.23	1					
Utilities	0.02	0.04	0.20	-0.29	-0.03	0.11	0.14	0.16	0.24	0.10	1				
Europe	-0.26	-0.37	-0.16	0.45	-0.08	-0.05	0.09	-0.11	-0.02	0.06	-0.15	1			
N.Amer	0.28	0.49	-0.14	-0.31	-0.24	0.18	-0.21	-0.05	-0.13	-0.12	-0.11	-0.62	1		
Global	-0.25	-0.03	0.01	-0.01	-0.10	0.04	0.07	-0.07	0.04	-0.01	-0.08	0.03	0.04	1	
World	0.03	0.02	0.40	-0.26	0.39	0.01	0.14	0.26	0.20	0.13	0.38	-0.54	-0.30	-0.15	1

To highlight the deviations from the results provided in equity prices and credit spreads correlation matrices, in table 6, we present the result from subtracting both coefficients (equity – credit). As can be noted from the table, the deviation on the correlation coefficients provided in tables 4 and 5 are noteworthy. For instance, *Global* and *Industrials* present a deviation of -0.90, followed by *World* and *Financials* 0.83. For most coefficients, the correlations provided in the equity prices table differ from those provided in the credit spreads table, even showing the opposite sign.

Table 6 Differences between correlations on equity prices and credit spreads

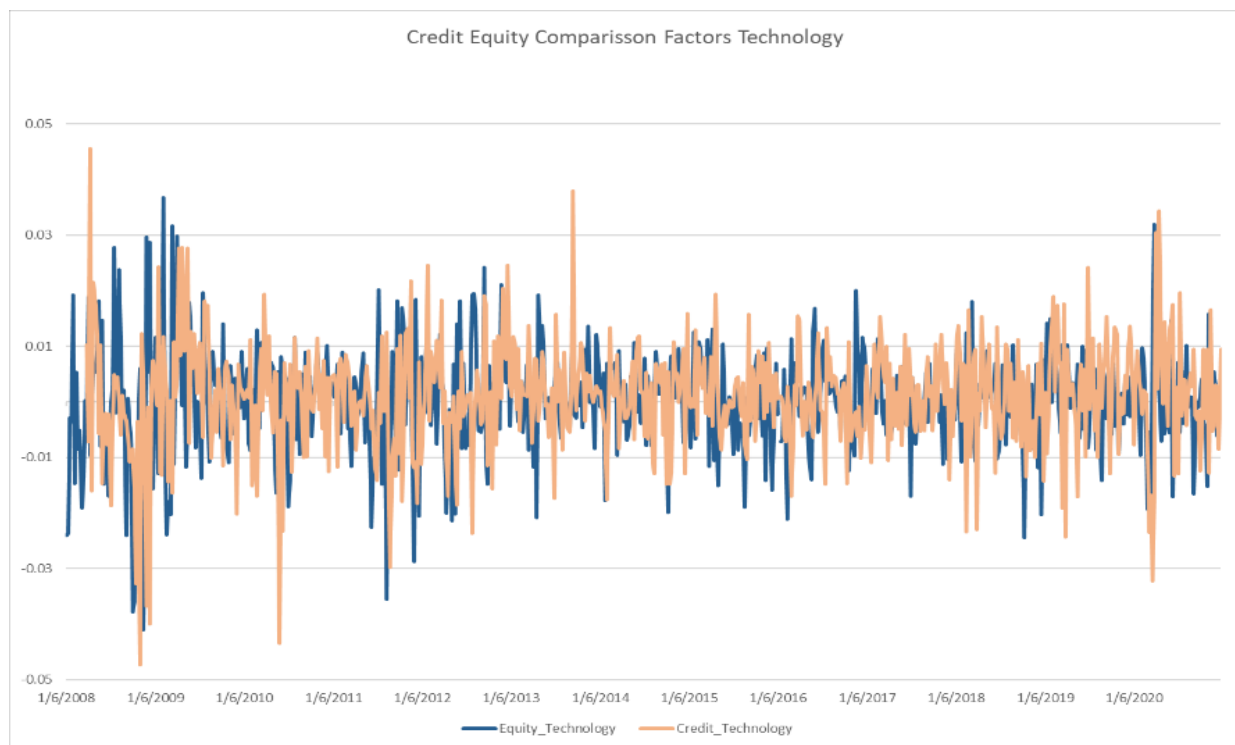
FACTOR	ConsGood	ConsServ	Energy	Financials	Healthcare	Industrials	Materials	Technology	Telecommunications	Utilities	Europe	N.Amer	Global	World
ConsGood	0	-0.24	-0.11	0.34	-0.22	-0.12	-0.58	0.32	-0.21	-0.33	0.61	-0.43	0.24	-0.28
ConsServ		0	-0.05	0.16	0.53	0.05	-0.10	-0.16	-0.10	0.23	-0.08	0.23	-0.22	-0.30
Energy			0	0.28	-0.24	-0.13	-0.22	-0.14	-0.63	-0.21	0.23	0.06	-0.26	-0.43
Financials				0	-0.19	0.48	0.39	0.40	0.43	0.29	-0.53	-0.09	0.15	0.83
Healthcare					0	0.21	-0.06	0.15	-0.13	-0.07	-0.02	0.23	-0.50	-0.30
Industrials						0	-0.57	0.28	-0.09	-0.52	0.20	0.13	-0.90	-0.41
Materials							0	-0.31	-0.40	0.19	-0.12	0.10	0.09	0.10
Technology								0	-0.10	-0.54	0.31	-0.15	-0.68	-0.27
Telecommunications									0	-0.43	0.10	0.10	-0.13	-0.33
Utilities										0	-0.42	0.36	0.27	0.16
Europe											0	-0.08	-0.17	0.03
N.Amer												0	-0.11	0.08
Global													0	0.31
World														0

#### 5.4 Individual factor analysis

In this section, we focus on individual factors. We study Consumer Services, Consumer Goods, *Technology*, *Utilities*, *Financials* and *World* as they present noteworthy disparities in their correlation values between credit spreads and equity prices.

In figure 5, we show the results from *Technology*. As can be noted from the figure, credit factors (in orange) present some spikes that are not present in equity data (in blue). The most notorious are those from 4/13/2008, 15/09/2013 and 3/22/2020.

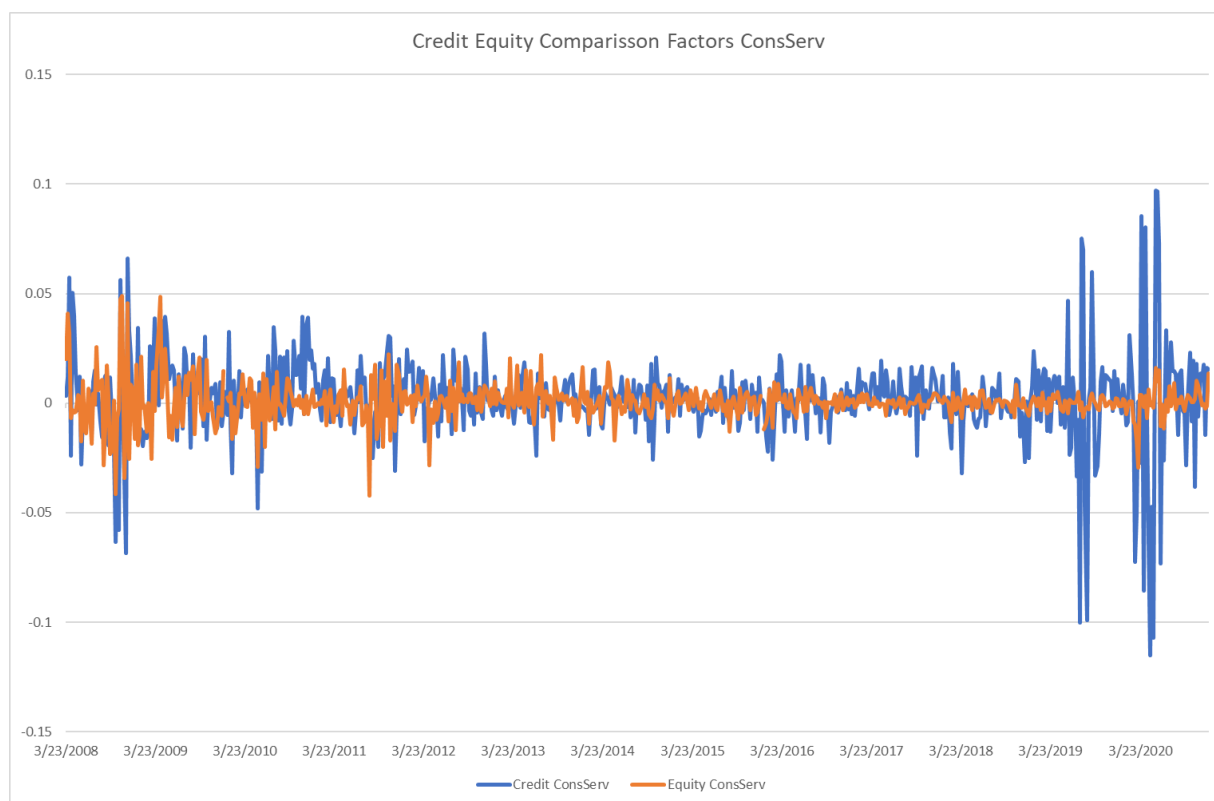
Figure 5 *Technology*: Equity prices vs credit spreads



In figure 6 we show the results from *ConsServ*. The first spikes around 2008 can be associated to strong movements into the bonds of the company *Hertz*. The company was not present into the equity list during the financial crisis as we only considered the stock after the spinoff of July 2016. This brings up an interesting consideration regarding how to handle certain corporate events in the model. The latest movements of the factors in 2020 can be associated to dramatic movements in *Hertz* credit spreads

due to the rumors and subsequent filing for bankruptcy of the company. It is noteworthy to observe that while the company stocks also display substantial fallings in price, this was done in a more constant manner. In contrast, in credits movements we observe bigger jumps which explain the spikes in the factors, as can be seen in the figure.

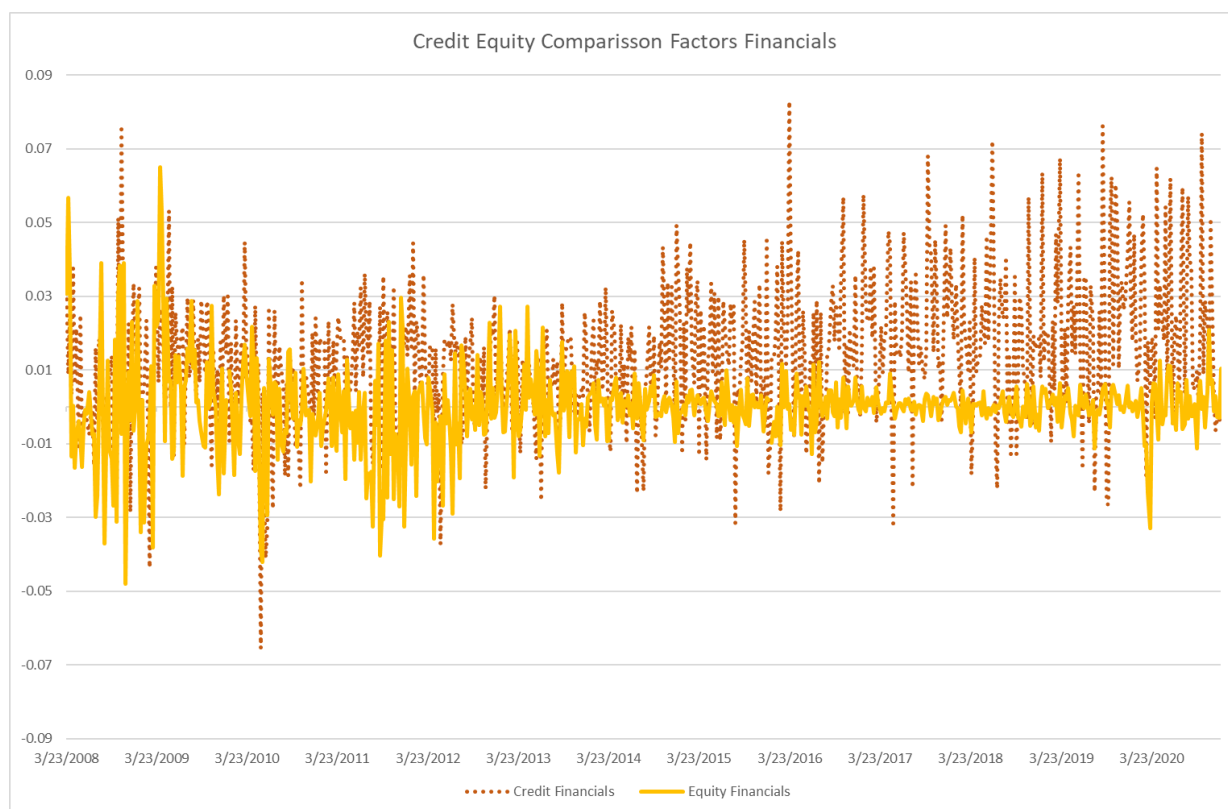
Figure 6 ConsServ: Equity prices vs credit spreads



In figure 7, we compare credit spreads and equity prices in *Financials*. As can be noted from the figure, a first spike takes place by the end of 2008. This is caused by a decreasing price trend of the financial stocks, which is not so evident on credit markets. From 2016 to early 2020 the volatility of credit spreads is higher than the one of equities. Finally, the spike of March 2020 shows that equity prices reacted in a much more stressed manner than the bonds did, there is no doubt that the bonds have been affected by the central Bank intervention<sup>55</sup>.

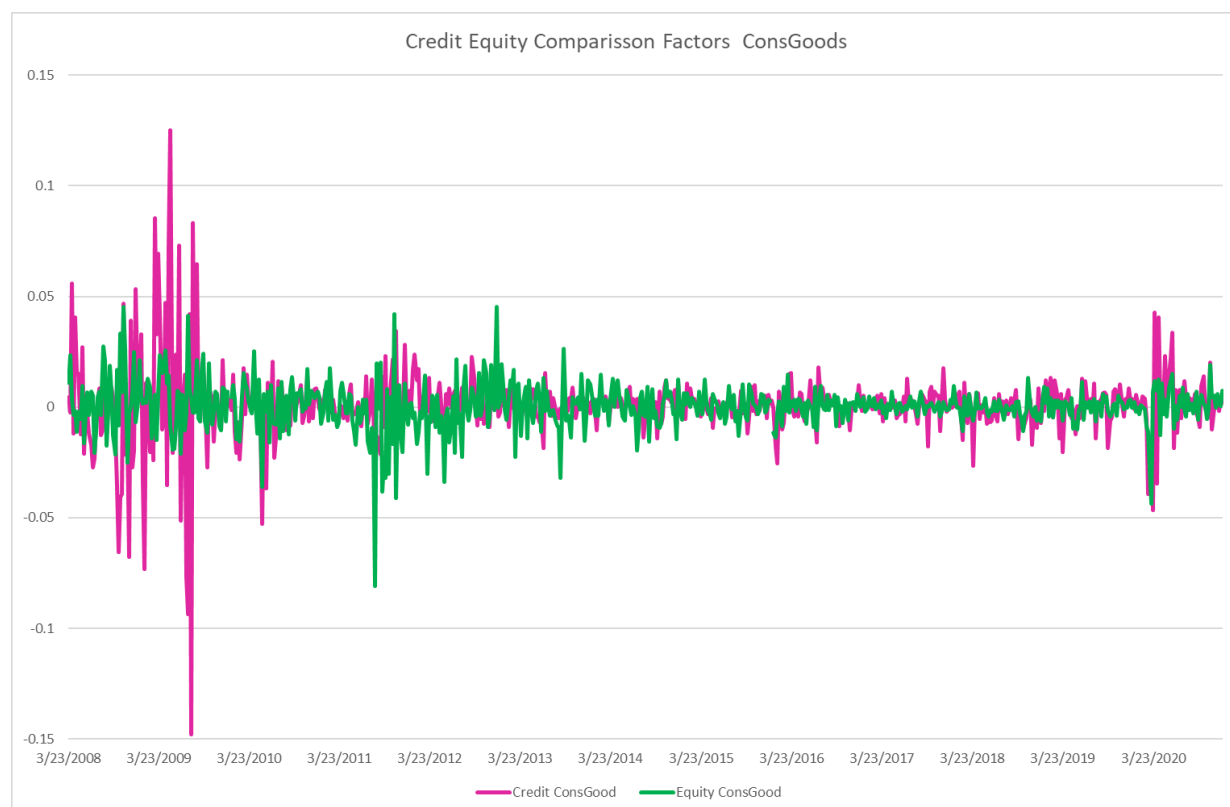
<sup>55</sup> [https://www.ecb.europa.eu/press/pr/date/2020/html/ecb.pr200318\\_1~3949d6f266.en.html](https://www.ecb.europa.eu/press/pr/date/2020/html/ecb.pr200318_1~3949d6f266.en.html)

Figure 7 Financials: Equity prices vs credit spreads



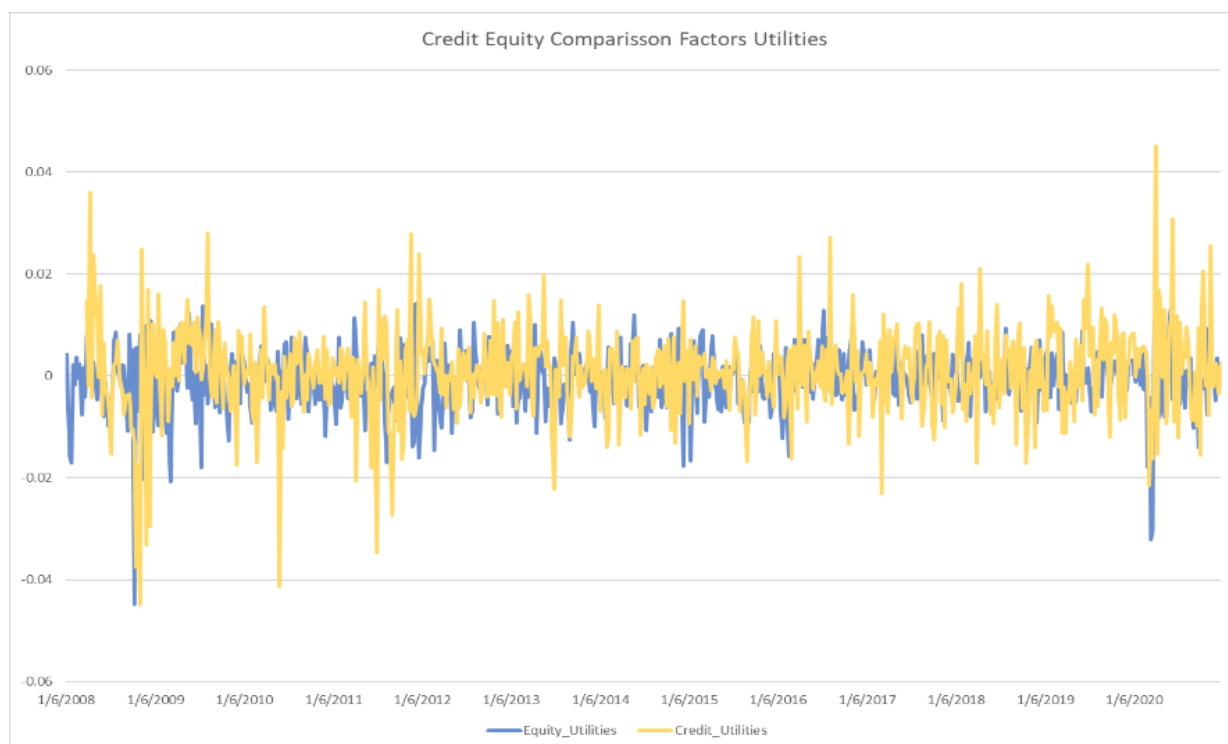
In figure 8 we observe the *ConsGoods*. The first spike in the credit can be linked to movements in the Amern Axle & Mfg Hldgs Inc bonds. While the last spike in 2020 seem to be caused by a dramatic movement in *KB Home*, this company also presents a profound movement into the equity level despite not as hard as in the bond spread. Eventually, we can conclude that mechanisms on the exchange can flatten certain equity spikes as the auction mechanism ensures not to overcome certain thresholds not available for bonds.

Figure 8 ConsGoods: Equity prices vs credit spreads



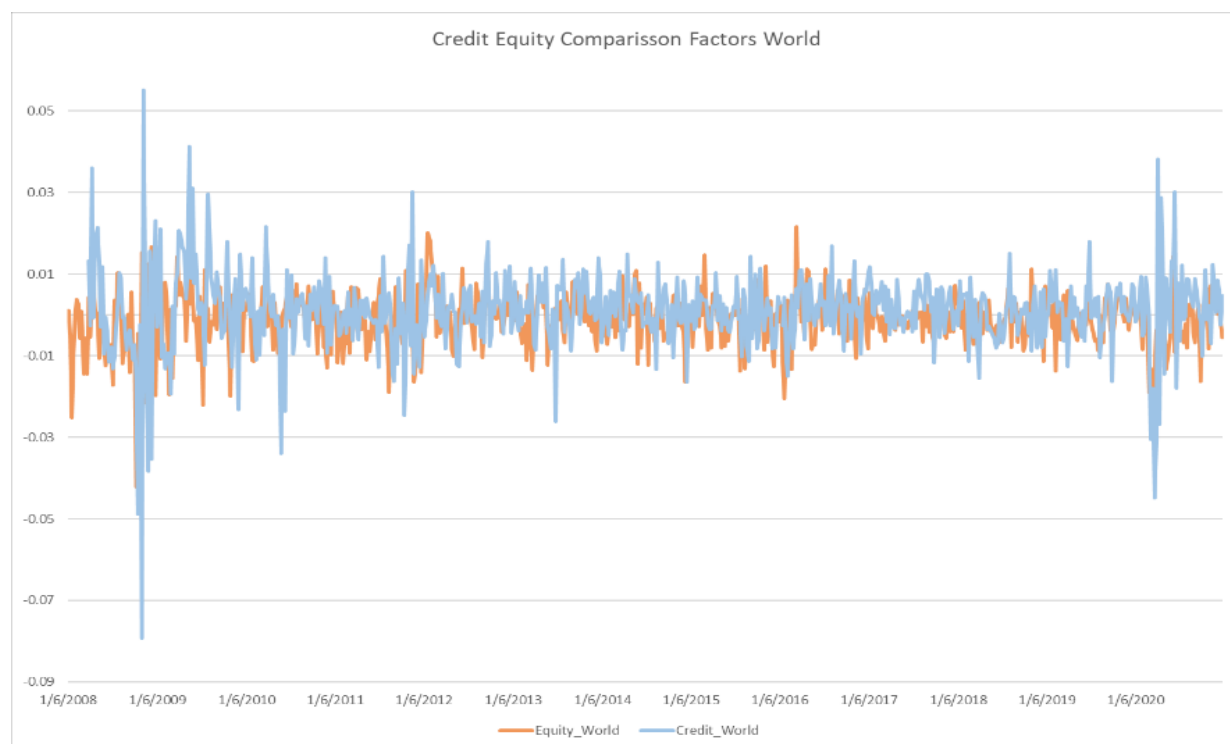
Looking at *Utilities* in figure 9, we observe a similar pattern between the equity and credit spread factors. Despite, across time there are periods in which credit seems to have more prominent movements. However, there are a few spikes that are worthy to review (5/30/2010, 7/03/2011 and 3/15/2020). The first two dates represent larger movement in credit while the last shows a deeper movement in equity. Looking at 5/30/2010, we observe that the spreads vary above the sector average, while in the equity side only one of the stocks had a relative similar movement but limited to 4%. The second spike was caused by similar reasons, the variations of credit spreads were deeper than those of stocks. The third spike, during March 2020, corresponds to the stock market crash after COVID-19 pandemic, this case highlights that during a market distress, the stock market overreacts debt market.

Figure 9 Utilities: Equity prices vs credit spreads



When looking at figure 10, we observe the *World* region factors where credit and equity exhibit similar trends, except for a noteworthy spike in the end of 2008 showing a more intense movement in the bond market, and in March 2020 due to bonds outside Europe and N. America whose sell off might not be mitigated by central bank stimulus plans.

Figure 10 World: Equity prices vs credit spreads



In conclusions, these observable discrepancies between credit and equity are aligned with Campbell and Ammer, 1993; Fama and French, 1993; Norden & Weber, 2009; Marsh & Wagner, 2012; who shows differences in how equity and credit relate to each other across time. There are a few remarkable deductions after observing the factors; firstly, despite the overall movements in the equity prices can be bigger over a period they tend to do it in a more consistent way while in the credit spreads are more susceptible to bigger jumps. Secondly credit spreads do not have Circuit breakers in their trading which can explain severe movements. Thirdly we can assume that the central bank intervention via different purchase programs can help to soften the movement of credit spreads. Fourthly different corporate actions events affect in a different manner the equity prices and credit spreads and hence the factors obtained through these two imputes.

### 5.5 Model simulation

In this section we run a simulation to test differences in the default predictions when using credit spreads and equity prices. To do so, we generate 1000 random scenarios, for which we obtain the

standardized issuer returns on each security. To define default, we establish a threshold of -2.33 which results of calculating the inverse of the standard normal cumulative distribution. This threshold is compared against the standardized issuer return per scenario. We consider the issuer default when the values are below the threshold.

In order to do this estimation, we use the weekly data. The standardized issuer returns  $\hat{X}_i$ ,  $i = 1, \dots, d$  are simulated according to the formula:

$$\hat{X}_i = \sqrt{\frac{v}{W}} \left[ \sqrt{\frac{R_i^2}{\Phi_i}} \left( b_0 \hat{Z}_0 + \sum_{j=1}^p \delta_{i,j} \mathbf{b}_{i,j} \hat{Z}_j \right) + \sqrt{1 - R_i^2} \hat{\epsilon}_i \right]$$

Where:

$\mathbf{Z} \in \mathbf{R}^p$  is the risk factor returns, with  $p < d$ , and follows a t-copula with correlation  $\rho$  and degree of freedom  $v$

$\mathbf{W}$ : a  $\chi^2$ -distributed random variable with parameter  $v$ , independent of  $\mathbf{Z}_j$

$R_i^2$ : the r-squared from the linear regression for issuer  $i$

$\epsilon_i$ : the idiosyncratic error terms, and follow a t-copula with correlation the unit matrix and degree of freedom  $v$

$\mathbf{B} = (\mathbf{b}_{i,j})$  is the factor loading matrix

$$\phi_i = \sum_{j=0}^p \sum_{k=0}^p \delta_{i,j} \delta_{i,k} b_j b_k \text{cov}(Z_j, Z_k)$$

$$\delta_{i,j} = \begin{cases} \mathbf{1} & \text{if issuer } i \text{ is affected by risk factor } j \\ \mathbf{0} & \text{otherwise} \end{cases}$$

To simplify the notation and to facilitate computation it is useful to switch from a subscripted notation to a matrix representation.

$$\hat{\mathbf{X}} = \sqrt{\frac{\nu}{W}} (\Omega \Delta \hat{\mathbf{B}} \hat{\mathbf{Z}} + \hat{\Omega} \hat{\epsilon}),$$

Were

$$\left\{ \begin{array}{l} \hat{\mathbf{Z}} \sim \mathcal{N}(0, \Sigma), \hat{\epsilon} \sim \mathcal{N}(0, \mathbf{I}_d) \\ \Omega = \text{diag} \left( \sqrt{\frac{R_1^2}{\Phi_1}}, \dots, \sqrt{\frac{R_d^2}{\Phi_d}} \right) \\ \Delta = (\delta_{i,j})_{i,j} \\ \hat{\mathbf{B}} = \text{diag}(b_0, \dots, b_p) \\ \hat{\Omega} = \text{diag} \left( \sqrt{1 - R_1^2}, \dots, \sqrt{1 - R_d^2} \right) \end{array} \right.$$

and  $\Sigma$  is the covariance matrix of the vector  $Z$ . The pairwise correlation  $\gamma_{i_1, i_2}$  between any two issuers can be expressed in closed form as

$$\gamma_{i_1, i_2} = \frac{\nu}{\nu - 2} \left( \sqrt{(1 - R_{i_1}^2)(1 - R_{i_2}^2)} \mathbf{1}_{\{i_1 = i_2\}} + \sqrt{\frac{R_{i_1}^2 R_{i_2}^2}{\Phi_{i_1} \Phi_{i_2}}} \sum_{j=0}^p \sum_{k=0}^p \delta_{i_1, j} \delta_{i_2, k} b_j b_k \text{cov}(Z_j, Z_k) \right)$$

In figures 11 and 12, we observe the graphic representation of the aggregated weekly returns for the 1000 scenarios performed. Figure 11 shows the histogram of equity returns and figure 12 shows the histogram for credit yields. As can be noted from the graphs, the equity distribution is slightly skewed to the left while the credit distribution is more aligned with a normal distribution. Moreover, the distribution of figure 11 is also more disperse than that of figure 12, suggesting the model run with equity data to throw riskier outputs.

Figure 11 Equity simulation asset value factor copula

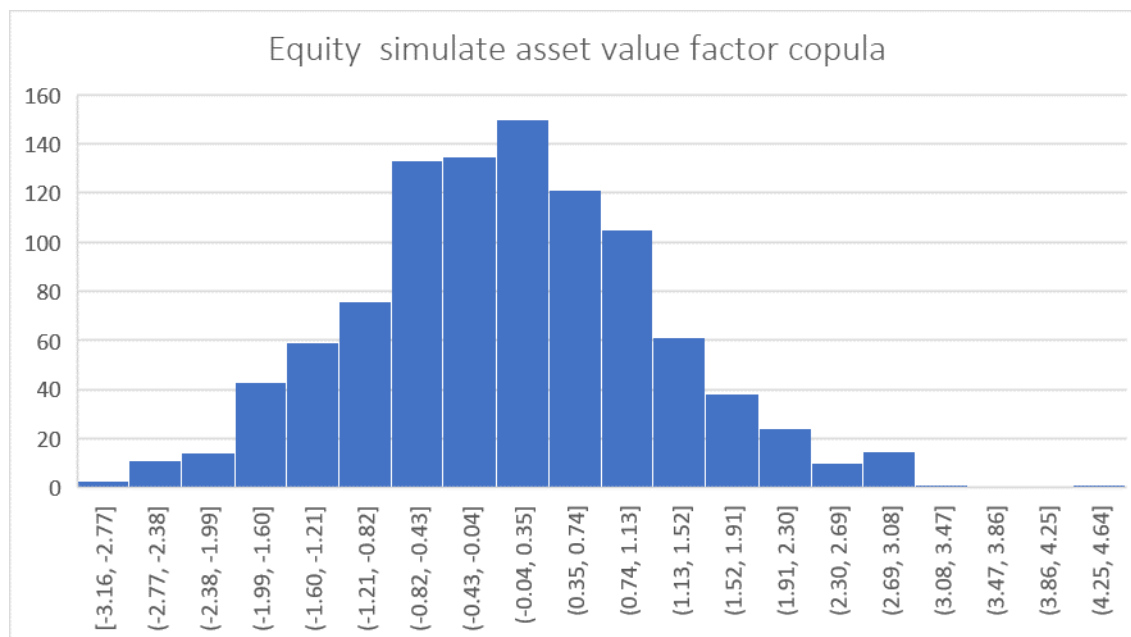
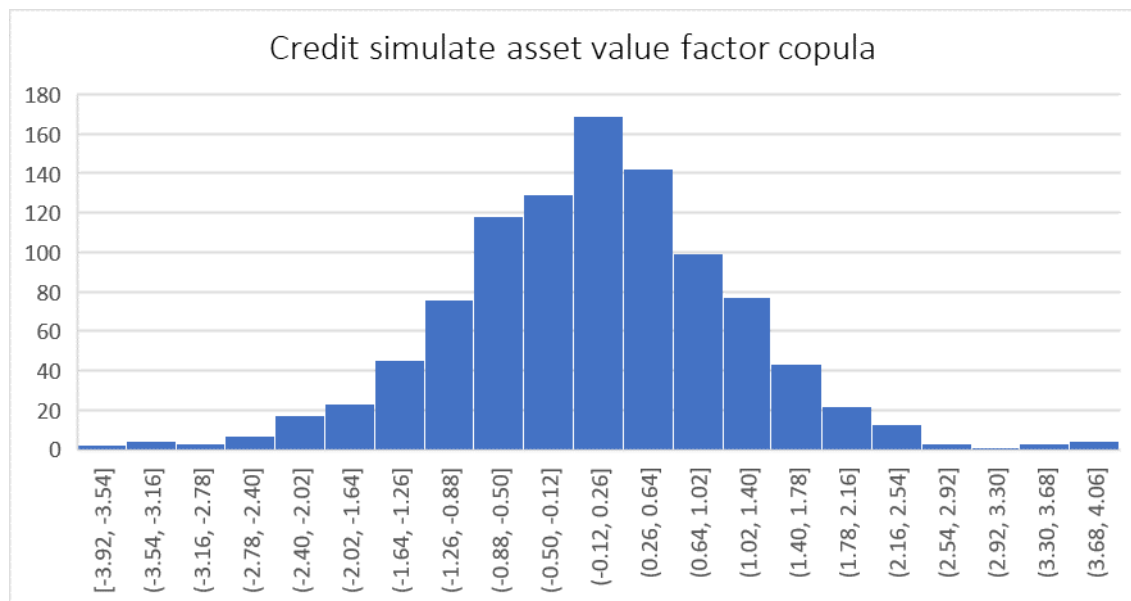


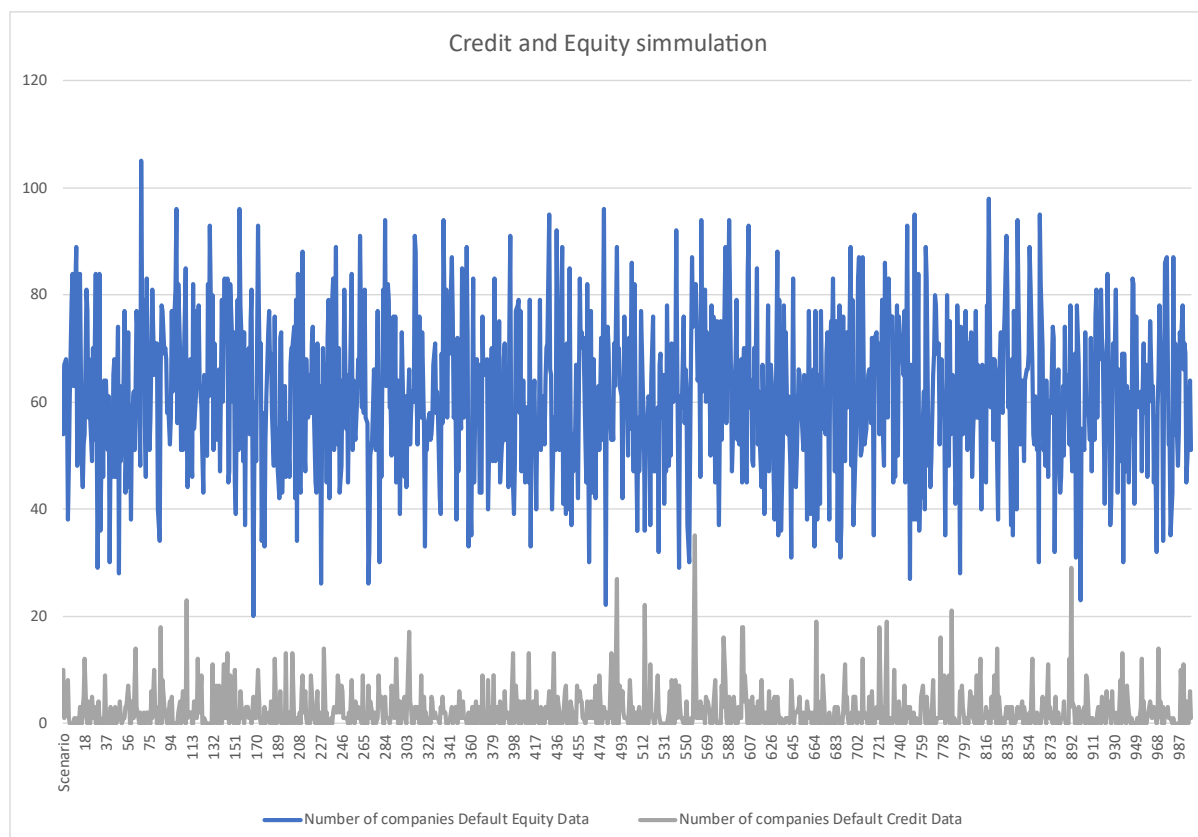
Figure 12 Credit simulation asset value factor copula



In figure 13 we represent the aggregated results from the 1000 simulation scenarios. The “x” axis represents the different scenarios while the “y” axis shows the number of defaulted companies. As

can be noted from the table, the number of expected defaults tend to be significantly higher when equity weekly rates of returns (in blue) than when bond weekly yields (in grey) are used as a risk proxy. These simulations suggest that vastly different outputs are to expect depending on the security used to proxy risk of default.

Figure 13 Default comparisons simulation Credit spreads vs Equity factor prices



## 6. Summary and conclusions

The forthcoming FRTB implements several methodological changes which include a two-factor default simulation model in the internal model approach for DRC. The data source to calibrate the model, assess risk and determine capital ratios, could come from either equity prices or credit spreads, and must cover a period of at least ten years (BSBS1; 2019).

This paper aims to shed some light on the limitations of the DRC which might lead to inadequate regulatory capital because of risk miscalculation. An incorrect bank capitalization could damage the solvency of banks and, consequently, the real economy as limitations in the supply of credit to the private sector may arise (Budnik et al. 2019). Our empirical implementation of the DRC under the FRTB regulation allows us to see how the type of security used in the model impacts the estimation on the obligor default and, by extension, the risk measurement.

In our study, we analyze how the implementation of the DRC produces different outputs depending on data sources (i.e.: equity prices versus credit spreads). These differences are translated into the factors, and, by extension, into the correlation matrix<sup>56</sup> used in the default model estimation.

We observe relevant aspects affecting the data availability that might affect the results. For instance, there is debt information available on private companies, and or governmental and/or supranational institutions thus there are more observations on debt than equity. These observations can affect the factors calculation -despite in some cases its effect can be limited due to the liquidity levels of these

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<sup>56</sup> Kendall's tau is used for calculation of default correlation and volatility correlation (El Ouadghiri et al, 2016, Luciano, 2005), due to the stability of this methodology and its robustness as an estimator for correlations (Tchernitser & Rubisov, 2009).

instruments<sup>57</sup>. Also, regarding credit spreads there is a simplification of the management of certain corporate action events which do not affect the price in the proportion it does for equity data<sup>58</sup>.

The relevance of our prior comment is also proven in this paper. In fact, in our analysis, we show how the factors are susceptible to outliers' observations. We analyze a synthetic index sample with and without outliers. Through this, we can test how the inclusion of more volatile companies can be translated into the factor values and the correlation matrix.

Looking at the differences in the correlation matrix between credit and equity data, we observe important differences in particular sectors (Campbell and Ammer, 1993). Subsequently we compare the equity and credit factors across time to try to explain the source of the difference. We observe how potential central bank interventions might have reduced the volatility of certain credit spreads during Pandemic emergency purchase program (PEPP) initiated by the ECB in March 2020. This is in line with the prior empirical investigation of Manganelli (2012) who analyses that purchases program during the Great Financial Crisis<sup>59</sup> contributed to a volatility reduction of the targeted bond yields.

We also observe a different behavior of equity and credit factors across time. In line with the literature, we verify how the relation between the bond and equity prices can vary across time and how during certain periods the factors seem to behave similarly (Campbell & Taksler, 2003; Sangbae et Francis; 2005).

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<sup>57</sup> Assuming that in the model there are implemented thresholds to control for liquidity.

<sup>58</sup> The bond price reaction to announcements of large dividend changes is opposite to the stock price reaction Dhillon, Upinder, and Johnson (1994)

<sup>59</sup> Orphanides (2010)

As hypothesize, we can observe how the price input affects the return simulation. As a conclusion in our portfolio, we detect that the equity prices simulate returns with a tendency to be positively skewed. In opposition, credit spreads follow a normal distribution. Additionally, the volatility tends to be higher for equity. This difference is fundamental as higher volatility on the returns might affect the risk perception (Guo, 2007).

In this paper we test the FRTB regulation applicable for the banks in the following years. We show how the factors (region and sector) accepted by the FRTB model implementation through student-t copula model are sensitive to outliers and how this sensitivity will transmit to the default correlation and even to the simulation returns.

The conclusions of this study can be used by the regulators and banks to understand how the data selection is implemented and to avoid incur in capital arbitrage at the DRC implementation. As explained prior the regulation, institutions that follow this approach must have clearly defined guidelines and procedures in place to determine which positions are included in the trading book and special attention should be given to the explain the data selection and how outliers are treated as it has been proved they can affect the end result.

Further research might consider banks portfolios particularities or focus on the effect of equity prices and credit spreads in a sample with a higher sector and/or region granularity.

## References:

- (Aretz and Pope, 2011), Aretz, Kevin and Bartram, Söhnke M. and Pope, Peter F., Asymmetric Loss Functions and the Rationality of Expected Stock Returns (October 13, 2009). International Journal of Forecasting, Vol. 27, No. 2, pp. 413-437, April-June 2011, WBS Finance Group Research Paper No. 61, Available at SSRN: <https://ssrn.com/abstract=889323> or <http://dx.doi.org/10.2139/ssrn.889323>
- (Blanco et al., 2005). Blanco, Roberto & Brennan, Simon & Marsh, Ian. (2004). An Empirical Analysis of the Dynamic Relationship between Investment Grade Bonds and Credit Default Swaps. Journal of Finance. 60. 10.2139/ssrn.478825.
- (Bonollo et al, 2018). Bonollo, Michele & Di Persio, Luca & Prezioso, Luca. (2018). The Default Risk Charge approach to regulatory risk measurement processes. Dependence Modeling. 6. 309-330. 10.1515/demo-2018-0018.
- (Brigo, Pallavicini, Torresetti, 2010) Brigo, Damiano and Pallavicini, Andrea and Torresetti, Roberto, Credit Models and the Crisis, or: How I Learned to Stop Worrying and Love the CDOs (December 29, 2009). Available at SSRN: <https://ssrn.com/abstract=1529498> or <http://dx.doi.org/10.2139/ssrn.1529498>
- (BSBS, 1996) Basel Committee on Banking Supervision. 1996.amendment to the capital accord to incorporate market risks. Retrieved from: <https://www.bis.org/publ/bcbs24.pdf> (Last accessed 8 November 2020)
- (BSBS, 1996) Basel Committee on Banking Supervision. 2013.amendment to the capital accord to incorporate market risks. Retrieved from: <https://www.bis.org/publ/bcbs24.pdf> (Last accessed 8 November 2020)
- (BSBS, 2004) Basel Committee on Banking Supervision. 2004. International Convergence of Capital Measurement and Capital Standards. Retrieved from: <https://www.bis.org/publ/bcbs107.pdf> (Last accessed 8 November 2020)
- (BSBS, 2008) Basel Committee on Banking Supervision. 2008. International framework for liquidity risk measurement, standards and monitoring. Retrieved from: <https://www.bis.org/publ/bcbs165.pdf> (Last accessed 8 November 2020)
- (BSBS, 2008) Basel Committee on Banking Supervision. 2008. International framework for liquidity risk measurement, standards and monitoring. Retrieved from: <https://www.bis.org/publ/bcbs165.pdf> (Last accessed 8 November 2020)
- (BSBS, 2008) Basel Committee on Banking Supervision. 2008. Principles for Sound Liquidity Risk Management and Supervision. Retrieved from: <https://www.bis.org/publ/bcbs107.pdf> (Last accessed 8 November 2020)
- (BSBS, 2009) Basel Committee on Banking Supervision. 2009. Guidelines for computing capital for incremental risk in the trading book. Retrieved from: <https://www.bis.org/publ/bcbs159.pdf> (Last accessed 8 November 2020)
- (BSBS, 2010) Basel Committee on Banking Supervision. 2010. Developments in Modelling Risk Aggregation. Retrieved from: <https://www.bis.org/publ/joint25.pdf> (Last accessed 8 November 2020)

- (BSBS, 2011) Basel Committee on Banking Supervision. 2011. Basel III: A global regulatory framework for more resilient banks and banking systems. Retrieved from: <https://www.bis.org/publ/bcbs165.pdf> (Last accessed 8 November 2020)
- (BSBS, 2012) Basel Committee on Banking Supervision. 2012. Fundamental review of the trading book (consultative paper 1). Retrieved from: <http://www.bis.org/publ/bcbs219.pdf> (Last accessed 8 November 2020)
- (BSBS, 2013) Basel Committee on Banking Supervision. 2013. Fundamental review of the trading book: A revised market risk framework (consultative paper 2). Retrieved from: <http://www.bis.org/publ/bcbs265.pdf> (Last accessed 8 November 2020)
- (BSBS, 2015) Basel Committee on Banking Supervision. 2015. Fundamental review of the trading book: Outstanding issues (consultative paper 3). Retrieved from: <https://www.bis.org/bcbs/publ/d305.pdf> (Last accessed 8 November 2020)
- (BSBS, 2016) Basel Committee on Banking Supervision. 2016. Minimum capital requirements for market risk. Retrieved from: <https://www.bis.org/bcbs/publ/d352.pdf> (Last accessed 8 November 2020)
- (BSBS, 2019) Basel Committee on Banking Supervision. 2015. ). CRE Calculation of RWA for credit risk. CRE53 Internal models method for counterparty credit risk. Retrieved from: [https://www.bis.org/basel\\_framework/chapter/CRE/53.htm?inforce=20191215&export=pdf](https://www.bis.org/basel_framework/chapter/CRE/53.htm?inforce=20191215&export=pdf) (Last accessed 8 November 2020)
- (BSBS, 2019) Basel Committee on Banking Supervision. 2015. ). Minimum capital requirements for market risk. Retrieved from: <https://www.bis.org/bcbs/publ/d457.pdf> (Last accessed 8 November 2020)
- (BSBS1, 2016) Basel Committee on Banking Supervision. 2015. Instructions: Impact study on the proposed frameworks for market risk and cva risk. Retrieved from: [https://www.bis.org/bcbs/qis/instr\\_impact\\_study\\_jul15.pdf](https://www.bis.org/bcbs/qis/instr_impact_study_jul15.pdf) (Last accessed 8 November 2020)
- (BSBS2, 2015) Basel Committee on Banking Supervision. 2015. Instructions for Basel III monitoring - Version for banks providing data for the trading book part of the exercise. Retrieved from: [https://www.bis.org/bcbs/qis/biiimplmoninstr\\_feb15.pdf](https://www.bis.org/bcbs/qis/biiimplmoninstr_feb15.pdf) (Last accessed 8 November 2020)
- (BSBS2, 2016) Basel Committee on Banking Supervision. 2016. Basel Committee membership. Retrieved from: <https://www.bis.org/bcbs/membership.html> (Last accessed 8 November 2020)
- (BSBS3, 2015) Basel Committee on Banking Supervision. 2015. Instructions: Impact study on the proposed frameworks for market risk and cva risk. Retrieved from: [https://www.bis.org/bcbs/qis/instr\\_impact\\_study\\_jul15.pdf](https://www.bis.org/bcbs/qis/instr_impact_study_jul15.pdf) (Last accessed 8 November 2020)
- (BSBS4, 2015) Basel Committee on Banking Supervision. 2015.. Basel Committee on Banking Supervision Glossary. <https://www.bis.org/cpmi/publ/d00b.htm?&selection=138&scope=CPMI&c=a&base=term>

- (BSBS3, 2016) Basel committee on banking supervision explanatory note on the revised minimum capital requirements for market risk (2016).
- (Budnik et al.,2019) Budnik, Katarzyna Barbara and Affinito, Massimiliano and Barbic, Gaia and Ben Hadj, Saifeddine and Chretien, Edouard and Dewachter, Hans and Gonzalez, Clara I. and Hu, Jenny and Jantunen, Lauri and Jimborean, Ramona and Manninen, Otso and Martinho, Ricardo and Mencia, Javier and Mousarri, Elena and Naruševičius, Laurynas and Nicoletti, Giulio and O'Grady, Michael and Ozsahin, Selcuk and Pereira, Ana Regina and Rivera-Rozo, Jairo and Venditti, Fabrizio and Trikoupis, Constantinos and Velasco, Sofia, The Benefits and Costs of Adjusting Bank Capitalisation: Evidence from Euro Area Countries (July 15, 2019). Banco de Espana Working Paper No. 1923 (2019), Available at SSRN: <https://ssrn.com/abstract=3419995> or <http://dx.doi.org/10.2139/ssrn.3419995>
- (Campbell & Taksler, 2003) John Y. Campbell, & Glen B. Taksler. (2003). Equity volatility and corporate bond yields. *The Journal of Finance* (New York), 58(6), 2321-2349. doi:10.1046/j.1540-6261.2003.00607.x
- (Campbell and Ammer, 1993) John Y. Campbell, & John Ammer. (1993). What moves the stock and bond markets? A variance decomposition for long-term asset returns. *The Journal of Finance* (New York), 48(1), 3-37. doi:10.1111/j.1540-6261.1993.tb04700.x
- (Clemente et al 2014) Di Clemente, Riccardo & Chiarotti, Guido & Cristelli, Matthieu & Tacchella, Andrea & Pietronero, Luciano. (2014). Diversification versus Specialization in Complex Ecosystems. *PLoS one*. 9. e112525. 10.1371/journal.pone.0112525.
- (Cont and Minca 2008) Cont, R. and Tankov, P. *Financial Modelling with Jump Processes*. London, Chapman and Hall/CRC, 2004
- (EBA, 2018) European Banking Authority. 2018. Implementing Basel III in Europe. Retrieved from <https://eba.europa.eu/regulation-and-policy/implementing-basel-iii-europe> (Last accessed 8 November 2020)
- (EBA, 2020) European Banking Authority. 2018. EBA publishes final draft standards on key areas for the EU implementation of the FRTB. Retrieved from <https://eba.europa.eu/eba-publishes-final-draft-standards-key-areas-eu-implementation-frtb> (Last accessed 8 November 2020)
- (ECB, 2018) European Central Bank. ECB guide to internal models Risk-type-specific chapters. 2018. ECB library. Retrieved from : [https://www.bankingsupervision.europa.eu/legalframework/publiccons/pdf/internal\\_models\\_risk\\_type\\_chapters/ssm.guide\\_to\\_internal\\_models\\_risk\\_type\\_chapters\\_201809.en.pdf](https://www.bankingsupervision.europa.eu/legalframework/publiccons/pdf/internal_models_risk_type_chapters/ssm.guide_to_internal_models_risk_type_chapters_201809.en.pdf) (Last accessed 8 November 2020)
- (Errais et al. 2007) Errais, E., Giesecke, K., Goldberg, L. R., and Barra, M. S. C. I. Pricing credit from the top down with affine point processes. *Numerical Methods for Finance*, 2007. 195-201.
- (European Commission, 2013) European Commission. 2013. Capital Requirements - CRD IV/CRR – Frequently Asked Questions. European Commission. Brussels. Retrieved from: [https://ec.europa.eu/commission/presscorner/detail/en/MEMO\\_13\\_690](https://ec.europa.eu/commission/presscorner/detail/en/MEMO_13_690) (Last accessed 7 November 2020)

- (Fama and French, 1993) Fama, E. F., & French, K. R. (1993). Common risk factors in the returns on stocks and bonds. *Journal of Financial Economics*, 33(1), 3-56. doi:10.1016/0304-405X(93)90023-5
- (Fan and Mitchell, 2017) Jack Fan, Marci Mitchell. 2017. Equity-Bond Correlation: A Historical Perspective. *Graham Capital Management Research Note*, September 2017  
Available at [https://www.grahamcapital.com/Equity-Bond%20Correlation Graham%20Research 2017.pdf](https://www.grahamcapital.com/Equity-Bond%20Correlation%20Graham%20Research%202017.pdf) (Last accessed 29 May 2021)
- (FED, 2013) Federal Reserve Cleveland. 2013. What Shape Is Commercial Bank Capital In?. Retrieved from : <https://www.clevelandfed.org/newsroom-and-events/publications/economic-trends/2013-economic-trends/et-20130322-what-shape-is-commercial-bank-capital-in.aspx> (Last accessed 8 November 2020)
- (Fischer et al 2009) Fischer, Matthias & Kock, Christian & Schluter, Stephan & Weigert, Florian. (2009). An empirical analysis of multivariate copula models. *Quantitative Finance*. 9. 839-854. 10.1080/14697680802595650.
- (Genest et al, 1995) Genest, C. & Ghoudi, Kilani & Rivest, Louis-Paul. (1995). A Semiparametric Estimation Procedure of Dependence Parameters in Multivariate Families of Distributions. *Biometrika*. 82. 10.1093/biomet/82.3.543
- (Giesecke and Kim, 2007) Giesecke, K. and Kim, B. Estimating tranche spreads by loss process simulation. In *2007 Winter Simulation Conference, 2007*. 967-975. IEEE.
- (Ghosh and Qureshi, 2017) Ghosh, Atish R. and Ostry, Jonathan D. and Qureshi, Mahvash Saeed, *Managing the Tide: How Do Emerging Markets Respond to Capital Flows?* (March 2017). IMF Working Paper No. 17/69, Available at SSRN: <https://ssrn.com/abstract=2967424>
- (Ghosh and Qureshi, 2019) Ghosh A. R. and Qureshi M.S. 2019. *From Great Depression to Great Recession : The Elusive Quest for International Policy Cooperation*. IMF. ISBN/ISSN 9781513514277/ Retrieved from <https://www.imf.org/en/Publications/Books/Issues/2017/06/02/From-Great-Depression-to-Great-Recession-The-Elusive-Quest-for-International-Policy-43657> (Last accessed 8 November 2020)
- (Glasserman and Xu, 2014) Glasserman, P., & Xu, X. (2014). Robust risk measurement and model risk. *Quantitative Finance*, 14(1), 29-58. doi:10.1080/14697688.2013.822989
- (Goodhart, C 2011): *The Basel Committee on Banking Supervision: A history of the early years 1974-1997*, Cambridge University Press. Retrieved from: <http://www.academicstar.us/UploadFile/Picture/2019-9/2019925171810900.pdf>
- (Guo, 2007) Hui Guo, "Higher Risk Does Bring Higher Returns in Stock Markets Worldwide," *Economic Synopses*, No. 19, 2007. <https://doi.org/10.20955/es.2007.19>
- (Hull et al. 2005) Hull, John C. and Predescu, Mirela and White, Alan, *Bond Prices, Default Probabilities and Risk Premiums* (March 9, 2005). Available at SSRN: <https://ssrn.com/abstract=2173148> or <http://dx.doi.org/10.2139/ssrn.2173148>
- (Hull and White, 2004) Hull, J. and White, A. (2004). Valuation of a CDO and an n-th to default CDS without Monte Carlo simulation. *Journal of Derivatives*, 12:8{23.

- (Ingves, 2018). Ingves, S. Basel III: Are we done now? [Speech transcript]. Basel Committee on Banking Supervision. <https://www.bis.org/speeches/sp180129.htm> (published 29 January 2018)
- (Jones, 2000). Jones, D. (2000). Emerging problems with the Basel capital accord: Regulatory capital arbitrage and related issues
- (Lall 2009) Lall, Ranjit .2009. Why Basel II failed and why any Basel III is doomed, GEG Working Paper, No. 2009/52, University of Oxford, Global Economic Governance Programme (GEG), Oxford. Retrieved from <https://www.econstor.eu/bitstream/10419/196313/1/GEG-WP-052.pdf> (Last accessed 8 November 2020)
- (Laurent et al. 2015) Laurent, Jean-Paul & Sestier, Michael & Thomas, Stéphane. (2016). Trading book and credit risk: How fundamental is the Basel review?. Journal of Banking & Finance. 73. 10.1016/j.jbankfin.2016.07.002
- (Le Leslé and Avramova; 2012 )V. Lesle and S. Avramova. Revisiting risk-weighted assets. Technical report, Working paper, International Monetary Fund. 28, 2012.
- (Li, 2000) Li, David Xianglin, On Default Correlation: A Copula Function Approach (September 1999). Available at SSRN: <https://ssrn.com/abstract=187289> or <http://dx.doi.org/10.2139/ssrn.187289>
- (Longstaff and Rajan, 2008) Longstaff, F. A. and Rajan, A. An empirical analysis of the pricing of collateralized debt obligations. The Journal of Finance, 63(2), 2008. 529-563
- (Marsh & Wagner, 2012) Marsh, I. W., & Wagner, W. (2012). Why is price discovery in credit default swap markets news-specific? . Retrieved from <https://www.econstor.eu/bitstream/10419/87299/1/12-033.pdf>
- (Meucci et al., 2007) Meucci, A., Gan, Y., Lazanias, A., and Phelps, B. (2007). A portfolio managers guide to Lehman Brothers tail risk model. Lehman Brothers Publications.
- (Norden & Weber, 2009). Lars Norden Martin Weber The co-movement of credit default swap, bond and stock markets: an empirical analysis. European Financial Management, 15(3), 529–562. <https://doi.org/10.1111/j.1468-036X.2007.00427.x>
- (Orphanides, 2010) Orphanides, A. 2010. "Monetary Policy Lessons from the Crisis," Working Papers 2010-1, Central Bank of Cyprus.
- (Schwaab et al., 2016). Schwaab, Bernd and Koopman, Siem Jan and Lucas, Andre, Global Credit Risk: World, Country and Industry Factors (June 17, 2016). ECB Working Paper No. 1922, Available at SRN: <https://ssrn.com/abstract=2797390>
- (Wilkins and Predescu, 2018). Wilkins, Sascha and Predescu, Mirela, Model Risk in the Fundamental Review of the Trading Book: The Case of the Default Risk Charge (March 22, 2018). Journal of Risk Model Validation, Vol. 12, No. 4, 2018, pp. 1-26, Available at SRN: <https://ssrn.com/abstract=3053426> or <http://dx.doi.org/10.2139/ssrn.3053426>

# 3

## Conclusions

Through this dissertation we analyze several factors affecting market, credit, liquidity, and capital bank's risk exposure. While in the first paper the risk factors are studied at a broad level, considering institutions across Latam with quite different characteristics; size (bigger and smaller institutions), location (different countries) and regulatory (under different supervisors). In the second paper the analysis concentrates on understanding the relationship between the sovereign risk exposure and the risk factors of small European banks. Finally, in the last paper the analysis is even more focused, looking at upcoming market risk capital regulation developed by the Basel Committee on Banking Supervision in the Basel II framework and intended to be applied to banks' wholesale trading activities.

The first paper analyses the factors influencing the risk of commercial banks in Latin America from 1999 to 2013 using a panel data set of 13,365 observations. The analysis shows that well-capitalized banks exhibit lower risk and greater stability. It further shows that banks focused on traditional banking activities tend to be less risky. Also, in this analysis it can see the role that the interest rate levels play for the bank risk assumption; as Latin American banks have lower risk intake when higher interest rates exist, which might be a peculiarity of the region which indicates that Latin American banks work better in high interest rates scenarios where they can be more selective in their asset allocation.

In the second paper, it is shown that capitalization and credit quality determine the sovereign debt exposure of European LSIs. In fact, the results show that lower levels of capital increase sovereign debt exposure, as weakly capitalized banks tend to increase their sovereign debt exposure, as it requires little or zero capital. Unexpectedly, credit quality is negatively related to sovereign debt exposure. This result suggests that LSIs are more conservative institutions than larger banks, as only those with greater credit quality tend to have larger sovereign debt exposure. In contrast to larger financial institutions, the LSIs show a negative and significant relationship between the ratio of

nonperforming loans and sovereign debt exposure, suggesting that LSIs with stronger credit quality tend to invest in sovereign securities. When we analyze macroeconomic factors, we find a negative relationship between sovereign yield and the sovereign debt exposure of LSIs, which implies that there is no moral suasion from governments under distress. These results further indicate that LSIs, unlike larger financial institutions, do not follow a reach-for-yield strategy, as they reduce exposure to sovereign debt in distressed macroeconomic scenarios.

The third paper studies how the implementation of the DRC produces different outputs depending on data sources (i.e.: equity prices versus credit spreads). This work examines how the price input affects the return simulation used in the DRC. This work shows that the equity prices simulate returns with a tendency to be positively skewed. It also proves that volatility tends to be higher for equity, but against the expectations it is found that credit spreads follow a normal distribution. This difference is fundamental as higher volatility on the returns might affect the risk perception (Guo, 2007). It can also be observed a different behavior of equity and credit factors across time. In fact, the number of expected defaults tend to be significantly higher when equity weekly rates of returns rather than when bond weekly yields are used as a risk proxy.

Through this work we study many factors that influence and explain banking risk. The management and study of bank risk assumption is not simple, and this can explain why, across time, several banks have failed to manage their risk intake. But this difficulty of addressing risk has also been observed at regulatory frameworks. Proving that regulators have also failed to correctly supervise and/or measure the banks risk intake. There is no panacea for undesirable banking risk assumption. However, to prevent future crises and maintain a sound financial system there are some general premises which we should keep in mind; and accept and consider the uncertainty of bank risk. Moreover, we should

keep financial system history very present and admit that behind both banks and supervisors, humans can still sometimes succumb to their nature and their irrationality.

A banking crisis tends to occur due to a phenomenon which is or was unexpected and/or to which the effect was underestimated. As banking crises are most likely unavoidable, we can lower the probability of occurrence and the lessen the impact by understanding the past, the banking risk factors and the financial sector. For these reasons, all those bankers or supervisors could do is to analyze, learn from past financial and banking crises, and to put in place early warning systems, to prepare for future crises and to remain humble by accepting the unexpected and the unknown.

# References:

- (Ahamed, L. 2009). Ahamed, Liaquat. 2009. Lords of finance: The bankers who broke the world.
- (Brunnermeier et al 2013) Brunnermeier, Markus Konrad and Oehmke, Martin, Predatory Short Selling (October 2013). NBER Working Paper No. w19514, Available at SSRN: <https://ssrn.com/abstract=2338887>
- (Calomiris, 2010) Calomiris, Charles W., 2010. "Banking crises yesterday and today1," Financial History Review, Cambridge University Press, vol. 17(1), pages 3-12, April.
- (Caruana, 2012) Jaime Caruana. (27 March 2012). Morgan Stanley European Financials Conference [Speech]. Available at <https://www.bis.org/speeches/sp120403.pdf>
- (de Bandt, et al, 2000) de Bandt, Olivier and Hartmann, Philipp, Systemic Risk: A Survey (November 2000). Available at SSRN: <https://ssrn.com/abstract=258430>
- (ECB, 2021) European Central Bank. (2021, August 6). Financial stability. European Central Bank. <https://www.ecb.europa.eu/pub/financial-stability/html/index.en.html#:~:text=Financial%20stability%20can%20be%20defined,the%20unravelling%20of%20financial%20imbalances>
- Geithner, (2014) Timothy F., Geithner, 2014 Stress test: reflections on financial crises. First edition. New York: Crown Publishers.
- (Hardy and Pazarbasioglu , 1998) Daniel C. Hardy and Ceyla Pazarbasioglu, 1998, "Leading Indicators of Banking Crises: Was Asia Different?" IMF Working Paper 98/91 (Washington: International Monetary Fund).
- (Hicks , 1946) Hicks, J., 1946, Value and Capital: An Inquiry into Some Fundamental Principles of Economic Theory, Oxford: Clarendon Press.
- (Laeven and Valencia, 2018) Laeven, Luc & Valencia, Fabian. (2018). Systemic Banking Crises Revisited. IMF Working Papers. 18. 1. 10.5089/9781484376379.001.
- (Maddaloni and Scopelliti, 2019) Maddaloni, Angela and Scopelliti, Alessandro, Rules and Discretion(s) in Prudential Regulation and Supervision: Evidence from EU Banks in the Run-Up to the Crisis (May 22, 2019). ECB Working Paper No. 2284 (2019); ISBN 978-92-899-3546-3, Available at SSRN: <https://ssrn.com/abstract=3392813>
- (Ongena et al, 2019) Ongena, Steven & Popov, Alexander & Horen, Neeltje. (2019). The Invisible Hand of the Government: Moral Suasion during the European Sovereign Debt Crisis. American Economic Journal: Macroeconomics. 11. 346-379. 10.1257/mac.20160377.
- (Stulz, 2014) René M. Stulz, 2014. "Governance, Risk Management, and Risk-Taking in Banks," NBER Working Papers 20274, National Bureau of Economic Research, Inc.
- (Stefan et al, 2019) Avdjiev, Stefan and Giudici, Paolo and Spelta, Alessandro, Measuring Contagion Risk in International Banking (July 15, 2019). BIS Working Paper No. 796, Available at SSRN: <https://ssrn.com/abstract=3420344>

- (Stulz, 2016) Rene M. Stulz, 2016. "Risk management, governance, culture, and risk taking in banks," Economic Policy Review, Federal Reserve Bank of New York, issue Aug, pages 43-60.
- (Stulz, 2014) Stulz, Rene M., 2014. "Governance, Risk Management, and Risk-Taking in Banks," Working Paper Series 2014-10, Ohio State University, Charles A. Dice Center for Research in Financial Economics.