Macro-prudential financial regulation of banks after the crisis of 2008

By

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Declaration

This thesis and the accompanying publications have not previously been submitted by the candidate for a degree in this or any other university.

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Abstract

After the global financial crisis of 2008 policy makers around the world initiated a paradigm shift towards macro-prudential financial regulation of banks. As a consequence the regulatory authorities are tasked with the objective of “maintaining financial stability”.

This PhD analyses the potential of this paradigm shift and identifies some of the issues of its objective. If maintaining financial stability is not fulfilled, systemic risk can again lead to damages to the financial and real economy in the form of a credit crunch as seen in the early stages of the crisis of 2008.

From a practical perspective, the findings of this thesis provide useful support for policy makers by identifying the key challenges in times of distress: Manipulating the incentives of banks towards the objective of promoting financial stability, and identifying the biggest sources for systemic risk in the banking sector and preventing its propagation.

Within an academic context, this thesis contributes to the nascent field of qualitative and quantitative research on systemic risk and contingent convertible bonds (CoCos) for the recovery and resolution of struggling banks.

The conditional Value-at-Risk (CoVaR) methodology is a new approach to quantifying the systemic risk stemming from one particular bank. The empirical results of this thesis show that a bank’s systemic risk is dependent on the state of the financial environment. So, this methodology can help the new macro-prudential regulatory agencies in their supervisory review of a bank. However, the results can alter substantially, depending on the sample period.

CoCos automatically decrease the leverage of a bank upon a specific trigger event. The bank’s capital ratio is reinforced instantaneously, making it more loss-absorbent. This thesis proposes a design that circumvents most of the issues identified in the nascent body of research that could limit CoCos. Specifically, and contrary to most proposals, it reinforces the natural order of shareholders and other creditors. With this, the moral hazard of banks is reduced and financial stability promoted.

Key words: Macro-prudential regulation, Systemic risk, ΔCoVaR, Contingent convertible bonds.

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1 Introduction

To contain the damages during the global financial crisis of 2008, policy makers followed pure pragmatism. Containing a disastrous crisis as it unfolds was the goal. Hence propping up bank capital with bail-outs by the various governments were obvious solutions alongside relaxed monetary policy executed by central banks such as relaxing refinancing conditions for banks. The International Monetary Fund concluded that: “[p]olicy responses have been rapid, wide-ranging, and frequently unorthodox, but were too often piecemeal” (International Monetary Fund, 2009, p. 6). The financial environment was laden with uncertainty as to how deep systemic risk pervaded the financial system and governments and regulatory agencies would intervene. This did not allow for finding private sector solutions to struggling banks.

In the aftermath of the global financial crisis of 2008 policymakers around the world pushed for new regulations that address the urgent problems in the financial system that have been revealed by the crisis, especially among banks. The paradigm shift towards a macro-prudential approach to financial regulation is at the core of this undertaking. This is the topic of this PhD thesis.

In their report “Changing banking for good” the Parliamentary Commission on Banking Standards in the UK proposes to address banking regulation along five main themes: First, the responsibility of the individual must be increased, especially on the most senior levels of a bank, the board room. Second, on a firm level, corporate governance must be reinforced so that the bank is responsible for its own safety and soundness. Third, banking markets must empower consumers and hence, greater discipline is exercised on the banks. Fourth, the new role of the regulators in exercising judgement based on their new legal powers must be accompanied with responsibilities. And fifth, the responsibilities of the Government have to be specified to address future bank-related regulation.

These five themes can broadly be summarized along three distinctive fields: the first two themes address banks’ conduct directly, the third theme addresses the market environment in that all individual banks operate, and the final two themes focus on the role of the public authorities; those who regulate[1] banks with setting the legal framework, government, and those who directly supervise the regulated firms.

[1] Note that the terms “regulation” and “supervision” of banks are used interchangeably from here on. Regulators set the rules the regulated subjects like banks have to abide by and supervisors monitor whether the banks actually abide them. Chapter 3 deals with how regulatory agencies regulate and supervise banks, yet a separation and discussion of who sets the rules and who supervises is not subject of this thesis.

This thesis is restricted to banking which is defined as deposit-taking financial services and the payment system. The second component of contemporary finance is the shadow banking sector. This is the area that is beyond the reach of regulatory agencies. In the euro area assets held by the banking sector accumulated to 29.5 trillion Euros in 2012 after a sharp decline of 12 per cent compared to 2008 figures. The Organization for Economic Co-operation and Development (OECD) reports different numbers. The total banking assets in the Euro area EUR 32 trillion of which the top 30 European banks hold EUR 27 billion (Schoenmaker and Peek, 2014). In the United States, shadow banking has traditionally played a bigger role than traditional banking (Shin, 2011). At the outbreak of the crisis in 2007, the shadow banking sector shrank from US$ 20 trillion to US$ 15 trillion in 2013. Conversely, in the USA traditional banking sector grew from US$ 13 trillion in 1990 to US$ 17 trillion in 2007 (Pozsar *et al*., 2012).

This PhD thesis' contribution is organised around these three fields. The macro-prudential framework is the new regulatory background and defines the new regulatory objective of financial stability of the regulatory agencies (chapters 3 and 4). As of addressing issues of bank conduct, contingent capital is one of the latest tools policy makers have high expectations of (chapters 6 and 7). This thesis proposes how contingent capital can incentivise bank managers to abstain from unsustainable risk-taking, which in turn promotes financial stability. The market environment in which banks operate can threaten the stability of banks regardless of their own risk-taking strategy (chapter 2). Through this exposure, distress in the system can be contagious to the individual bank. At the same time the affected bank in distress can negatively affect the financial system. So, this systemic risk of the individual bank is a feedback effect (chapter 5) Again, contingent capital, as proposed in this thesis, can abate this threat.

The questions that motivate this PhD thesis are: How did it come to the crisis? What is systemic risk and how can it be measured? The regulatory response is "macro-prudence", but what exactly is it? Who identifies and judges systemic risk and puts macro-prudence into practice? What tools can be used to put "macro-prudence" into practice? And, finally, when we have the answers, does "macro-prudence" deliver? Can a financial crisis like the one of 2008 be avoided? In order to find answers to these questions the PhD thesis is organised as follows:

Chapter 2 recapitulates the global financial crisis of 2008. It analyses how it came to the crisis and how it spread in the global financial system, i.e. systemic risk. Consequently, the results of chapter 2 are used to derive the two core research questions that are answered in each of the following chapters:

- Does the topic of the particular chapter address the regulated institutions' incentives so that they abstain from taking unsustainable risks that can cause systemic crisis?
- If yet systemic risk emerges is the topic at hand able to limit its potential for further damages?

Each of the following chapters aims to add to anserwing these questions.

Chapter 3 discusses the macro-prudential regulatory framework and its different interpretations in the UK, USA, and EU. The macro-prudential framework is further divided into the regulations imposed on the banks and the architecture of the regulatory agencies in the respective jurisdiction.

Chapter 4 analyses the macro-prudential tools at the regulatory agencies' disposal. The "core" tools are flexible capital buffers with which the agencies can lean against the building up of price bubbles due to excessive lending by banks. In addition auxiliary tools like caps on bank managers' remuneration are discussed.

Chapter 5 contains an empirical analysis of systemic risk and adds a quantitative analysis to the qualitative analysis of chapter 2. One tool that the regulatory agencies can use to measure systemic risk is the conditional Value-at-Risk (CoVaR). The data used cover European banks' stock returns from 2002 to 2014. The analysis of each bank's systemic risk contribution is divided into three periods, i.e. pre-crisis period, crisis period, and post-crisis period.

After the crisis contingent capital gained the attention of policy makers. Briefly, these are bonds that upon a trigger event de-leverage a bank in order to increase its loss-absorbency. The chatper further distinguishes contingent covertibles (CoCos) as a special kind of contingent capital, because CoCos explicitly convert into new equity. CoCos can play an important role in the macro-prudential toolkit. Because of its importance to this thesis' contribution, two chapters are dedicated to this topic. Chapter 6 presents a critical discussion of the nascent literature on CoCos. The existing proposals deviate substantially in their features and there are concerns that they do not achieve a stabilisation but introduce instabilities. This can certainly not be in the interest of regulatory agencies.

The first part of chapter 7 contains an empirical analysis of CoCos and adds a quantitative analysis to the qualitative analysis of chapter 6. The data used comprises CoCo bonds of five of the largest European banks. The aim is to determine what factors affect the spread of returns of CoCos.

The second part of chapter 7 proposes a different CoCo design. Specifically, it is shown that the frictions identified in the existing literature can be overcome by amending CoCos with an exclusive call option for the new equity in which the CoCos are converted. It is shown that, in contrast to the findings of chapter 3, macro-prudence can be achieved through CoCos as a market-based instrument. Therefore, this PhD thesis argues that the current initiative towards a macro-prudential regulatory framework is too heavily geared towards emphasising the intrusiveness of regulatory agencies. Instead of moulding banks, as the regulated subjects, to fit the new regulatory paradigm, the motivation of this thesis is also to harness the very market-forces that led to the crisis in order to discipline banks to steer clear of taking unsustainable risks.

2 The global financial crisis of 2008: Causes and consequences to regulation

This chapter revises the global financial crisis of 2008, its sources, and consequently its implications for future financial regulation. Section 2.1 gives a brief overview about the key events of the financial crisis. Section 2.2 cites the costs of dealing with the crisis that emerged from these events. Section 2.3 derives the similarities with and differences to previous crises in order to identify the gaps in the incumbent regulatory paradigm and clear the way for macro-prudential regulation. Section 2.4 gives more detail on how securitisation was at the centre of the crisis. Consequently section 2.5 embeds the macro-prudential regulation paradigm into the economic theories of financial crises. This chapter further identifies systemic risk as a permanent risk that needs to be addressed by this paradigm. Section 2.6 concludes and defines the research questions that build the research framework for the following chapters.

2.1 Timeline of the crisis and policy responses

This section summarises some of the key events of the global financial crisis of 2008. In order to derive suggestions how financial regulation should counter financial crises in the future, it is necessary to trace it back to its origins and how it spread out in the global financial markets. A full overview can be obtained through the websites of the European Central Bank (ECB) (2015a) and the Federal Reserve Bank of New York (2015).

The U.S. Federal Reserve Bank of St. Louis traces the global financial crisis back to 27 February 2007, the date the Federal Home Loan Mortgage Corporation (alias Freddie Mac) stopped buying subprime mortgages and mortgage-related securities.

Only weeks later, on 2 April, New Century Financial Corporation, a leading subprime lender, files for Chapter 11 bankruptcy protection and was the first casualty to the events that would soon unfold.

As a consequence of defaulting mortgage payments of consumers, Standard and Poor’s and Moody’s, two of the biggest credit rating agencies, downgraded over 100 bonds related to subprime-mortgages on 1 June 2007.

The first action of a public authority to curb a panic in the financial markets took place when the U.S. Federal Reserve Bank announced that it “will provide reserves as necessary” (Board of Governors of the Federal Reserve System, 2007) in addition to the continuously available discount window as a source of funding. Furthermore, the notion that “[i]n current circumstances, depository institutions may experience unusual funding needs because of dislocations in money and credit markets” (Board of Governors of the Federal Reserve System, 2007), in retrospective, turns out to be the declarative statement that there is a full-grown crisis and not mere temporary disruptions.

In Europe, public authorities were forced to undertake actions analogous to the authorities in the USA. The 14th of September 2007 marks the outbreak of the crisis in Europe when the Bank of England provided liquidity support to Northern Rock, one of the UK’s largest mortgage lenders. How Northern Rock experienced the crisis is provided later in section 2.4.5. This bank’s experience during the crisis serves as a case study how the interconnectedness of banks with the global financial system gives importance to systemic risk as a permanent threat to the stability of the financial system. The weeks of late summer of 2007 were the transition phase from what originally started as a domestic subprime lending crisis in the USA towards a full grown global financial crisis.

On 17th February 2008 Northern Rock was taken into public ownership by the Treasury of the United Kingdom (BBC News, 2008); the first of several European banks to be taken into public ownership.

In March 2008 the Federal Reserve introduced two more tools to bolster stability in addition to a prolonged Term Auction Facility programme, i.e. holding central bank borrowing at historical low levels. The US$ 200 billion big Term Securities Lending Facility (TSLF) allowed exchanging a variety of securities for Treasury securities. The Primary Dealer Credit Facility (PDCF) had an even broader definition of eligible securities that could, in contrast to TSLF, be deposited for instant cash. Different kinds of securities were accepted for collateral in order to hinder markets from drying up. On 24th March 2008 the Federal Reserve Bank of New York pledged to provide financial support to JP Morgan Chase & Co.’s acquisition of Bear Stearns Companies Inc. Instead of being recorded on JP Morgan’s books, a limited liability company received Bear Stearns assets worth US$ 30 billion, of which the majority were placed as security for a US$ 29 billion primary credit line at the Federal Reserve. JP Morgan Chase assumed the US$ 1 billion.

In July the Federal Reserve Board reinforced its pledge to lend to Federal National Mortgage Association (Fannie Mac) and the Federal Home Loan Mortgage Corporation (Freddie Mac) “should such lending prove necessary” (Board of Governors of the Federal Reserve System, 2008).

Several reports from across the globe push for a regulatory paradigm shift to address the issues stemming from the interlacement of development on the micro level to the macro level. For example, on an international stage the International Monetary Fund (2008) derive the need for a "macrofinancial stability framework to help improve supervision and regulation at the domestic and global levels" (p. 7). The need for co-ordinating macrofinancial stability soon developed into the task to create a macro-prudential financial regulation framework.

In the European Union (EU), notable documents are the de Larosière Report (2009) that derives various recommendations to initiate a global agenda to address the shortcomings of the existing regulatory framework. Chapter 3 analyses the various initiatives in the UK, USA, and EU in more detail. Nevertheless, key recommendations are *inter alia* the orderly resolution of struggling banks so that the need for using taxpayers' money is minimal, mandatory separation of significant trading activities in a bank, a review of banks' loss-absorbing capital requirements and regulatory influence in banks' governance. Examples for the latter are the nurturing of a more risk-sensitive, i.e. prudent, culture at banks and sanctioning powers of the regulatory agencies in the form of lifetime professional ban on individual managers and deferring compensation.

In the UK, the Turner Review by the Financial Services Authority (2009) (henceforth referred to as Turner Review (2009)) underscored the consequences to the intellectual challenge to comprehend system wide risk. Furthermore the review finds that regulatory agencies (then the UK Financial Services Authority before the UK Prudential Regulation Authority was founded) must be more intrusive and take a systemic view in their supervision of financial institutions. The challenge is to identify how certain lending practices at financial institutions, i.e. micro-level, have significant impacts one the financial system as a whole, i.e. macro-level. The same is identified in the USA in the Financial Crisis Inquiry Commission (2011) and Permanent Subcommittee on Investigation (2011). The securitisation of sub-prime mortages in section 2.4 is an example for this.

2.2 Costs of mitigating the crisis

This section reports the costs of containing the immediate damages of the crisis and the long-term costs to the economies. Countering the adverse shocks with short-term liquidity injections was an appropriate tool for central banks. So, for example, the ECB injected EUR 94.8 billion for one day to ease the tension in the financial markets; the Federal Reserve Bank of New York injected US$ 24 billion; and the Bank of England provided the British banking system with guarantees and loans worth GBP 500 billion. (Lee, 2010).

The International Monetary Fund (2008) estimated the losses from the initial sub-prime crisis to US$500 billion but follow on losses because of a contracting banking business tend to US$1.4 trillion, threefold the initial shock.

The indirect losses of the aftermath of a financial crisis can be permanent (Haldane, 2010). So, for the years 2008 to 2018 the foregone gross domestic product in the USA is estimated to US$ 12.8 trillion (Feuerberg, 2008). Haldane (2010) estimates the figures for the UK to GBP 1.8 trillion and for the global economy to US$ 60 trillion.

In conclusion, the previous section shows how local developments in the U.S. market spread out to the international financial markets. The evidence suggests that the global interconnectedness of financial institutions is a breeding ground for a consistent threat of contagion. However, this new class of risk could not be contained by market forces alone. It required substantial efforts by national authorities in the form of co-operation and money. In addition, taxpayers' money needed to be used and thus was not available for other policies to boost national economic programmes. These opportunity costs of foregone investments add to the cost of the crisis.

2.3 Comparison of the global financial crisis of 2008 to other financial crises

This section underscores the macro-prudential paradigm shift by comparing the crisis of 2008 to previous financial crises. For a general overview of financial crises, see Kindleberger and Aliber (2005). How is the crisis of 2008 different to previous financial crises? What does the crisis of 2008 have in common with previous financial crises? If the crisis of 2008 is different to previous financial crises then one has to raise the question if regulation *in general* can match developments in the financial system that leads to a crisis. Yet, if financial regulation can do so, why has the recent crisis not been avoided or mitigated? This question is even more relevant especially if the crisis was *not* too different from previous crises. If the crisis followed a similar script to preceding crises, then consequences for financial regulation have to be drawn. Important comprehensive work on answering this question was conducted by Reinhart and Rogoff (2009). The authors conclude that there were early warnings similar to those that caused previous financial crises. For instance, a rapid increase of housing prices in the USA of 100 per cent within few years was bound to burst eventually. Another indicator was the increase in public sector debt and household indebtedness. Yet this was not considered a problem by policy makers such as central bankers, see Greenspan (2007). Before the crisis, global financial integration prospered. This meant that countries could borrow from and through the global financial system with ease, especially the USA (O'Neill, 2002). Bernanke (2005) suggests that the then ongoing borrowing in the USA was due to a global savings glut.

The financial industry and especially the banking industry in the 21^{st} century are fundamentally different to some one hundred years ago, especially because banking and financial institutions operate in international markets. In order to justify regulation it is important to know why banks fail. If the problems of the new world of banking are different from the old, the regulatory catalogue has to change, too.

Back in the time of the Great Depression in the 1930s, to which the crisis of 2008 is often compared, in a study of 2,955 national bank failures in the USA from 1865 to 1936 O'Connor (1938) reports that the most common causes of a bankruptcy of a bank were local financial distress and incompetence of the bank's management. Interestingly, he claims, a loss of the public's confidence and the accompanying bank run accounted for just 5 per cent of bank failures. Note that in 1933 the U.S. Congress introduced the Federal Deposit Insurance Company (FDIC) to protect deposits as an answer to the crash of 1929 that caused the Great Depression of the 1930s. More recently Cottrell *et al*. (1995) conclude that banks fail because of common shocks, such as in real estate and oil prices, and not because of contagion from other banks without being exposed to the initial shock. However, the following sections show that bank interdependencies do cause contagion among banks.

Financial crises are frequent in number. The International Monetary Fund (1998) reports statistics for crises for the two decades from 1975 to 1997. The report further distinguishes between currency crises, currency crashes, banking crises, and currency combined with banking crises. Currency crises occurred 158 times and banking crises only 54 times across industrialised and emerging economies. However, with an average of 3.1 years banking crises last twice as long as currency crises. Of those crises that caused an output loss, i.e. a drop in GDP compared to a forecasted GDP trend, banking crises came at a loss of 14.2 per cent compared to 7.1 per cent for currency crises. The crises are distinct, however similarities can be identified: Asset prices increase – inflated housing prices are amongst the key indicators (Reinhart and Rogoff, 2009) – and at some point turn out to be a bubble, heavy accumulation of household and public debt, growth patterns, and current account deficits. Kaminsky and

Reinhart (1999) document that financial liberalisation precedes such crises (more recently Brunnemeier *et al*., 2009). This pattern reveals the picture that the failings of individual banks usually cluster (Kaufman, 1999) and concurrent failings, if large enough by the numbers, can be called banking crisis.

Yet, the state of the financial world has changed (see Crockett, 1997): A steep increase in financial transactions reflects the increased integration of global capital markets, highly complex financial instruments, costly crises, and high-profile scandals at individual financial institutions put financial stability in the spotlight.

Criticism arose about the securitisation business banks employed to generate a steady stream of income. In fact it is the excessive creation and securitisation of mortgages of low credit quality that distinguish the crisis of 2008. How the financial instrument "securitisation" works and what role it played in the build-up of the financial crisis is subject of the following sections. Securitisation was a key element in the propagation of losses from the U.S. mortgage business to overseas banks for it tied banks closer together. So, European banks were indirectly exposed to mortgages in the USA even though they did not issue them. This was when the U.S. sub-prime crisis of 2007 became the global financial crisis of 2008. The findings stated in the previous paragraphs must be put into perspective. Common shocks lead to the observation that several banks fail but today's financial and banking industry is more interconnected – *inter alia* through securitisation – and single common shocks are more likely to cause a chain reaction. Contemporary finance hence is accompanied by a shock-amplifying financial environment. The following sections give a qualitative analysis of how this amplification works. Each bank that is affected can drag down the rest of the system. This is also called the "systemic risk" stemming from the individual bank. A quantitative analysis of this systemic risk follows in chapter 5.

Yet, in addition to the macro-economic factors there are further factors that fed the global financial crisis of 2008. For example, Avgouleas (2012) finds five sources for the global financial crisis:

First, risk diversification turned out to be counterproductive. In order to diversify their risk exposure financial institutions and investors used Credit Default Swaps (CDS)[2] and other

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[2] A credit default swap (CDS) is a popular financial instrument to insure against credit risk. The holder of a CDS is the insurer, the issuer of a CDS wants to protect against the credit risk of a particular debt obligation. If a credit event occurs, the CDS holder replaces the original debtor and pays according to the CDS contract. Hence a CDS is an insurance against non-payment. In return, the CDS holder receives a fee for his contingent obligation to pay.

financial instruments that fall under the label “securitisation”. Theoretically, such instruments made available virtually every kind of risk available on the globe to create a risk portfolio according to one’s own preferences. However, the result was that at the outbreak of the crisis, financial markets were homogeneous “rather than diverse and well-balanced” (Avgouleas, 2012, p. 69).

Second, securitisation led to an alteration of accumulation of credit risk. So, household debt that is known to be a root cause for financial crises was distributed to the global financial system. Instead of resting with the originator of securitised risks, credit risk migrated to the balance sheets of capital market investors who usually lacked information about the underlying asset pools and had not had the quantitative skills to compute the true risk.

Third, the increased availability of investments to investors was accompanied by an increasing complexity of the network itself. The result was a longer chain (Shin, 2011) of the network from the basic underlying asset pool, the originator of the securities based on such pool, to monoline insurers who syndicated financing the off-balance sheet firms that in turn sold the securities to the final investor. The interconnectedness within the financial markets made it even more difficult to estimate the true risk of such investments.

Fourth, as a consequence of the heavy use of securitisation, the ‘originate-to-distribute’ model became popular among originators with disastrous implications for incentives. Making lending decisions, i.e. to ‘originate’ credit risk, was no longer based on the assumption of holding this particular risk until maturity. Instead, knowing that the securitised cash flow can be ‘distributed’ to the financial markets, originators held up a constant supply of credit risk that would not have necessarily passed their own due diligence requirements for sound investments. The next section analyses securitisation in more detail.

Fifth, leverage played a major role. The global overabundance of credit resources helped finance those securities and led to a prolonged period of financial tranquillity. This led to “irrational exuberance” (Greenspan, 1996) in the financial markets. As a result, “markets tended to make one way bets” (Avgouleas 2012, p. 97) and financial losses due to impairment of the value of these securities in consideration positively correlated. Confronted with declining market prices on their investments, investors had to have a fire sale of assets to avoid bankruptcy.

In conclusion, each of these factors can reinforce the others. Of these factors securitisation is special because it is a conduit for the unintended problems. On the one hand we see that savings in one part of the world can be made available for investment in another country – assuming that domestic law provides for lifting restrictions on international capital flow. The effectiveness of this financial integration depends on the structure of the financial system. So, a bank can originate a mortgage pool just to securitise its cash flow and borrow against it with someone who has excess savings somewhere in the global financial system.

The following section depicts the rationale for, and structure of, the securitisation process in order to fully understand how the interplay of these five factors eventually led to the crisis of 2008. Subsequently, the rationale is confronted with real evidence from the business practice.

2.4 The role of securitisation: Wrong incentives and propagation channel

This section and sub-sections investigate excessive use of securitisation and its role in building up the crisis of 2008. The global financial crisis was sparked by the U.S. sub-prime crisis of 2006. Mortgage-backed securities (MBS) comprised of securitised private mortgage pools, "Residential Mortgage Backed securities" (RMBS) and commercial mortgages, "Commercial Mortgage Backed Securities" (CMBS). From spring 2000 to summer 2001 the total issuance of new asset backed securities (ABS), including commercial real estates, non-U.S. residential mortgages, sub-prime home equity, automobile finance, student loans, and credit cards, accumulated to just under US$100 billion. The total issuance peaked in late 2005 and early 2007 with US$ 300 billion worth of ABS. Most notably, the securitisation of sub-prime home equity peaked at US$ 150 billion in the summer of 2006. From September on figures dropped sharply to zero in March 2008. With a delay of one year issuances of the other asset categories fell drastically shortly before September 2007, the anniversary of the sub-prime crisis. At the peak of the crisis in late 2008 the losses on sub-prime mortgage-related securities were estimated at US$ 500 billion (International Monetary Fund, 2008).

A further analysis of the theoretical rationale for securitising assets is helpful to understand how exactly losses from a pure domestic market for mortgages can spread to other countries so rapidly. Furthermore, the results feeds into the five reasons given in the previous section that led to the crisis.

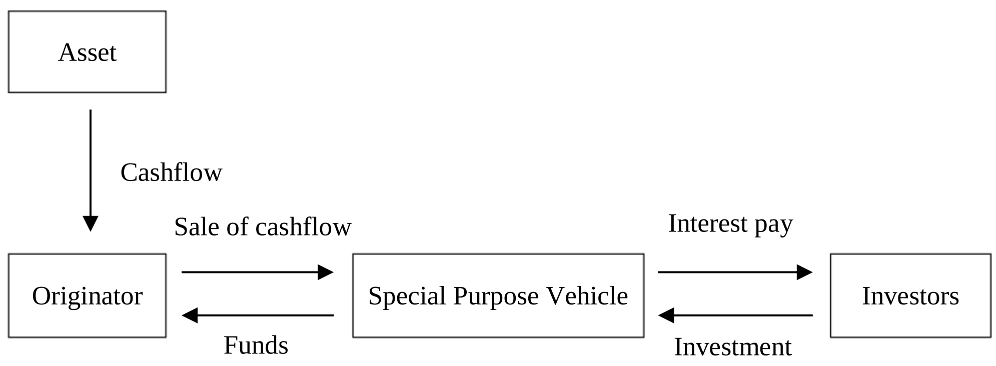
2.4.1 Introduction to the theoretical rationale of securitisation

This sub-section gives a brief introduction to the securitisation of the cash-flows of assets. The term “securitisation” refers to the process by which the securities are written and placed in the markets. According to Schwarcz (1994) securitisation is backed by the future cash flows of the underlying entity’s economic future. Shenker and Colletta (1991) resolve the possible confusion that there is a one tier structure between the underlying cash-flow generating entity and the security as warrant to claim the proceeds, securitisation is:

> “the sale of debt or equity instruments, representing ownership interests in, or secured by, a segregated, income-producing asset or pool of assets, in a transaction structured to reduce or reallocate certain risks inherent in owning or lending against the underlying assets and to ensure that such interests are more readily marketable and, thus, more liquid than ownership interests in and loans against the underlying assets” (p. 1374-5.).

This citation gives a more precise image for it emphasises the potential of shifting the level and composition of risk according to the intentions of the creator. Figure 2.1 illustrates the basic architecture of a securitisation.

Figure 2.1: Basic architecture of a securitisation. Source: Own illustration based on IOSCO (2008), Schwarcz (1994), and Schwarcz *et al*. (2004).



The underlying asset generates a cash flow available to the originator (for the following, see also Barmat, 1990; Schwarcz, 1994; Schwarcz *et al*., 2004: and International Organization of Securities Commissions, 2008). For example, a bank is the originator of a pool of mortgages that serves as the underlying asset. The mortgage payments, i.e. the cash flows, are collected frequently by the originator in order to be passed on to the securities. A special purpose vehicle (SPV), or synonymously “special-purpose entity” (Schwarcz *et al*., 2004, p.6) is created by the originator who cedes the claim of the cash flows to the SPV. The SPV is a separate legal entity and serves as fiduciary and sells the securities and distributes the cash flows to the final investor who holds the securities. At the time the SPV is created, the investor buys the securities from the SPV. The SPV is financed with little capital to continue operations irrespective of the bankruptcy of the originator (Dayan *et al*., 1990) and therefore is structured “bankruptcy remote” (Schwarcz, 1994, p. 30) to the bank. This securitisation process allows for an isolated view on the asset and its future cash flow independent from the originator’s own riskiness.

After the financial crisis of 2008 “financial innovation” has received a negative connotation. Innovation ought to be interpreted as improving services to the end consumer. However, the financial industry in the USA created off-balance sheet financing techniques, such as asset-backed securities, that:

> “[…] are efficient means of obtaining funding for their participants while simultaneously achieving accounting, tax and regulatory benefits of various types. They are well understood by the marketplace and reflect the innovation for which the U.S. capital markets are known” (Batson, 2002, p. 22).

This citation is taken from a first interim report on the bankruptcy of Enron, a large utility company, in 2001. There are various applications to the benefit of an originator, for example instantaneously increasing the liquidity of the particular firm. The role of this asset-backed securitisation process in the crisis of 2008 is further exemplified in the next section with the example of the securitisation of sub-prime mortgages in the USA.

Securitisation is not specifically defined in detail, for it is merely a concept that describes how a cash-flow from a certain investment opportunity is directed to a recipient. A definition by U.S. legislators for the term “securities” is given by referring to “any note, stock certificate, bond debenture, check, draft, warrant, […], certificate of interest in property, tangible or intangible” (18 U.S.C. § 2311, 1994).

The occurrence of payment disruptions can be countered with credit enhancements (Barmat, 1990; Fabozzi, 1993). The originator, despite the aim of decoupling the originator’s credit risk from the risk associated with the securitised assets, can pledge to take a fraction of the losses of the cash flow stream (Barmat, 1990; Fabozzi, 1993). In addition, specialised insurers give additional guarantees to pay a fraction upon a disruption for a predefined fee. To increase market acceptance, originators commission transactional lawyers and credit rating agencies to assist in the securitisation process (Barmat, 1990). In this light McBarnet (2010) argues that the driving force behind the financial crisis was also "legal engineering" that assisted the financial engineering of instruments. The role that legal engineering played was mainly to circumvent regulations by deliberately creating complexity and opacity. The next sub-sections analyse in more detail how banks were incentivised to issue mortgages of sub-prime quality due to securitisation and on top of the political agenda of the U.S. government.

2.4.2 Securitisation fostered the originate-to-distribute business model

This sub-section investigates the incentives to deliberately issue sub-prime mortgages for short-term profits that eventually destabilised the financial system. The rationale and possible advantages of securitisation are given in the previous section. However, until the 1990s mortgage securitisation in the USA was dominated by the government-sponsored enterprises Federal National Mortgage Association and the Federal Home Loan Mortgage Corporation, known as Fannie Mae and Freddie Mac, respectively, who also were the largest mortgage issuers. Both enterprises guaranteed the debt service on the securities. From the 1990s to the 2000s large private institutions entered the mortgage securitisation business and became leading in the securitisation of mortgages (Congressional Budget Office, 2010). However, in contrast to the government-sponsored enterprises, the debt service was not guaranteed by the private institutions.

The steady increase in housing prices was largely fed by historically low interest rates. The Standard & Poor's Case Shiller Home Price Index reports U.S. national housing prices appreciation of 8 per cent in 2003, 12 per cent in 2004, and 16 per cent in 2005 (Gerrity, 2011). In addition, this boom was fuelled by macro-imbalances such as an international savings glut that, via the mortgage-issuing part of the financial industry, produced the supply for such mortgages. The Turner Review (2009) gives a detailed overview of these macro-imbalances including oil prices and household debt in the USA, UK, and EU.

However, political pressure by the U.S. government and the U.S. Fed played a major role in fostering the sub-prime crisis (Frame et al., 2015). The loose monetary policy of the Fed to keep interest rates low was part of the U.S. government's efforts to make home ownership affordable to low-income households. Due to their role in putting in action the government's plan to make mortgages more affordable, Fannie Mae and Freddie Mac used the advantages of this public-private partnership – definitions can be obtained in Burger *et al*. (2009) and references therein – and increased their financial leverage. Even if this unsustainability was clear to some commentators and in deed among senior staff in the two companies (Duhigg, 2008), "serious reform efforts were portrayed as attacks on the American Dream and hence politically unpalatable" (Frame et al., 2015, p. 1). So, even the Federal Housing Finance Agency (FHFA), the regulatory agency in charge to supervise Fannie Mae and Freddie Mac, was limited in its power to challenge this mortgage business. Thus, the political agenda created a moral hazard problem for mortgage issuing firms.

The securitisation process that banks employed decoupled the generation of returns from the default risk of the underlying assets. Ultimately securitisation opened the door for the excessive creation of credit risk. The originating banks only held the mortgages with the intention to pass them on via securitisation and not to hold them until maturity. Banks faced only a "pipeline risk" (Brunnermeier, 2009. p. 82) of these risk conduits. This risk-return-decoupling was the start of an ill-aligned incentive structure for banks and their mortgage issuing front-office staff. Keys *et al*. (2010) give empirical evidence in support of declining credit quality of assets intended to be securitised. Through securitisation the original credit risk, i.e. the risk that a borrower defaults on payment on obligations, is made liquid and can be traded in markets. On the same token with the creation of such markets, market risk is created. This addresses the probability that an institution's asset declines in value.

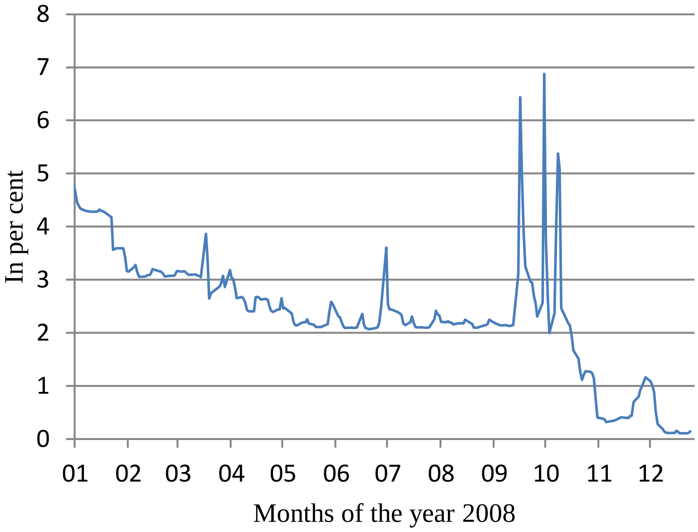
The overall "[b]orrower-friendly underwriting criteria" (Krinsman, 2007, p. 1) with additional "teaser rates" allowed mortgage takers to pay an artificially low rate in the first years. But the rate would adjust to a higher level in the following years. Another common practice, especially among sub-prime mortgages, was issuing a long-term loan to the mortgage taker that was specifically designed to pay back the rates on the initial mortgage. A combination of teaser rates and cross-selling specialised loans are called "risk layering" (Krinsman, 2007, p.3). The most extreme case was the issuance of NINJA ("no income, no job or assets") loans to the poorest credit quality of sub-prime mortgages without thorough documentation (Brunnermeier, 2009, p. 82). Under the premise of rising house prices, the bank could at least seize the house if the mortgage defaulted.

Consequently, in a joint statement on subprime mortgage lending the Office of the Comptroller of the Currency, Board of Governors of the Federal Reserve System, Federal Deposit Insurance Corporation, Office of Thrift Supervision, and National Credit Union Administration (2007) address the risks of the mortgage lending practice. Particular attention must be paid to the customers. One particular problem was that the lending arrangement exceeded customers' ability to repay and that the involved financial institutions did not exercise due diligence in documenting every aspect of the creditworthiness. Furthermore, a large portion of customers did not fully comprehend the benefits and risks associated with the mortgage and loan. The originate-to-distribute model was accompanied by "improper lending practices determined to be predatory or abusive" (Krinsman 2007, p. 8).

2.4.3 Tying the underlying mortgages to the LIBOR created procyclicality

In addition to the lax underwriting of mortgages, a further negative feature that turned out to be a design flaw was that the mortgage rates were tied to the interbank loan rates. These are the conditions at which banks borrow from each other for various short maturities, including overnight. The rate is a considerable factor for a bank's ability to raise funds. The most common rate is the London Interbank Offered Rate (LIBOR). Worldwide, an estimated US$ 150 trillion worth of financial instruments like mortgage-backed securities are indexed to the LIBOR. Figure 2.2 shows the U.S. Dollar LIBOR for overnight lending for 2008:

Figure 2.2: USD LIBOR in 2008. The x-axis indicates the months of the year 2008 and the y-axis denotes the London Interbank Offered Rate in per cent. Source: Federal Reserve Bank of St. Louis.



The rate remained stable at just over 2 per cent from April to August. In September 2008, when Lehman Brothers filed for bankruptcy, the rate almost instantaneously climbed to over 6 per cent. Consequently, mortgage borrowers who signed for a flexible rate had to pay an increased monthly rate. Eventually a substantial portion of mortgages defaulted across the board and put banks under further constraints. Banks could not collect payments on their issued mortgages in full. Refunding via the interbank market was also tight. So, the result was a banking industry wide credit crunch. This is the first piece of evidence that the initial risk associated with an asset, here mortgages, can be amplified within the financial system.

Note that from October 2008 on, the rate decreased which was not due to regaining trust among banks but rather the large-scale interventions by the U.S. Federal Reserve in the form of low charges for banks to use existing central bank facilities and newly established programmes. The impact of such programmes on the LIBOR rate are empirically supported by McAndrews *et al*. (2008).

2.4.4 Tranquil investor perception creating a fragile financial system

This sub-section discusses how carelessness among investors in the global financial markets was promoted by the very tools ought to capture riskiness.

A further aspect of the originate-to-distribute model banks employed but did not receive due attention is the discrepancy of credit risk and risk-weighted regulatory capital. According to the Bank for International Settlements, an international forum for central bankers to discuss global banking standards, henceforth abbreviated to BIS, banks are allowed to employ various methods to calculate how much capital they need for a specific credit risk, for example an issued mortgage. According to accounting requirements banks keep records of these investments held to maturity in the banking book; the trading book on the other hand keeps a record of those investments that the bank holds for trading purposes only therefore not held to maturity. The crucial difference is that assets in the banking book are held at historical costs and assets in the trading book are marked-to-market with methods such as the Value-at-Risk method. This method is subject to the empirical research on systemic risk in chapter 5. The general criticism of the Value-at-Risk model is explained in more detail there.

Before the crisis the capital requirements calculated for trading book assets were consistently lower and, unsurprisingly, banks exploited this gap to reduce their regulatory capital level. Eventually the originating banks securitised mortgages, removed them from their banking books, and passed them on to other banks that now would hold them in their trading books. The Turner Review (2009) emphasise that the overall asset growth on banks' balance sheets was captured in ballooning trading books, with little risk-sensitive capital to account for possible losses. It was only after the crisis that Basel II accord received an update, see Basel Committee on Banking Supervision (2009), henceforth abbreviated to BCBS.

Regulatory arbitrage was indeed a contributing factor to the crisis (Turner Review, 2009) and allowed to underestimate the leverage of banks. The special purpose vehicles connect the originator of the underlying assets and financiers in the financial system. By this process asset-backed securities could be removed from the originating bank's balance sheet. So the investors were not able to estimate the true leverage and therefore true risk of individual banks. On an aggregated level the risk of the financial system was underestimated.

This shows that the five sources of the crisis presented in section 2.3 are closely connected to each other. With securitisation the credit risk of an asset was made more liquid and removed from the originator to a willing investor in the financial system. The increased popularity of this originate-to-distribute business model led to a decline in lending standards. This negative aspect was widely ignored but willingness to lend against securitised assets increased, the result was that banks increased their leverage. With more parties involved in the process of securitisation and trading of such, the financial network became more complex. The unchecked credit risk creation did not stay at specific investors but circulated in the markets. So it was difficult to gauge who would suffer losses upon a credit risk event. Yet the perception was that this had been no reason to worry.

What from the individual bank's point of view was prudent created an inherently fragile system. The arguments according to financial theory for making available a vast selection of different kind of risk via securitisation in order to optimise a bank portfolio falls short of recognising the perversion of incentives. Along the chain these were, first, the originating bank that neglects due diligence; second, the financial system institutions, such as credit rating agencies and monoline insurers, who also perfunctorily checked the securitised assets; and, third, the final investors at the end of the chain, who faithfully believed in the previous groups' assessments. Furthermore, this chain of interconnectedness introduced instabilities within the structure of the financial system itself. These instabilities accumulated to what for regulators is the ultimate concern, systemic risk.

Now a further look at the propagation channels within the financial system: The securitisation process included credit enhancers such as CDSs provided by insurance companies. Among them was AIG. As a direct consequence of the sub-prime mortgage business, AIG had to be bailed out by the U.S. Federal Reserve with US$ 85 billion. The attached insurance service was greatly appreciated by the markets and the securities received best credit ratings. Lewis

(2011) identifies a large discrepancy between the insurance pay-out for outstanding US$ 20 billion of mortgages in the event of a default in exchange for a mere 0.12 per cent insurance fee per year.

Certain investment restrictions apply to institutional investors such as banks and pension funds (Permanent Subcommittee on Investigations, 2011). In some countries institutional investors are by law limited in holding investments below a certain quality precisely to counter systemic risk concerns. For example, for the restrictions in the USA, see section 28 (d) and (e) of the Federal Deposit Insurance Act. Such quality assessments can be exercised by the investors themselves. Because of the sheer number of available financial instruments that cover all kinds of investment opportunities, also sophisticated investors such as banks quickly reach their limit of computing power and can lose oversight. This gap of information asymmetry is filled by credit rating agencies' services. In the late 1990s the BCBS proposed a new capital adequacy framework, which became to be known as Basel II, introducing a "system that would use external credit assessments for determining risk weights" (p. 5). It is beyond this PhD thesis to address the role of credit rating agencies and especially their problematic role in the recent crisis. These aspects are analysed elsewhere, see for example Schwarcz (2002).

However, the rating grades attached to securitised mortgages – especially sub-prime – were confused with "high quality". The Permanent Subcommittee on Investigations (2011) in the USA identified credit rating agencies to have deliberately awarded mortgage-backed securities with high rating grades despite their awareness "of problems in the mortgage market, including an unsustainable rise in housing prices, the high risk nature of the loans being issued, lax lending standards, and rampant mortgage fraud" (p. 7).

As long as investors see that the consequences of a default event of an investment are abated with an insurance, they are prepared to invest in it. The fundamental issue is found at the beginning of the chain of securitisation: the quality of assets. Even though a looming liquidity or credit bubble was identified it was more "profitable to ride the wave than to lean against it" (Brunnermeier, 2009, p. 82), see also Abreu and Brunnermeier (2002) for a theoretical model of such an incentive.

2.4.5 How the U.S. sub-prime crisis led to the global financial crisis

The previous sub-sections show how the sub-prime mortage market in the USA emerged. This sub-section highlights how the collapse of this domestic market evolved into a global financial crisis through the interconnectednedness of the global financial system.

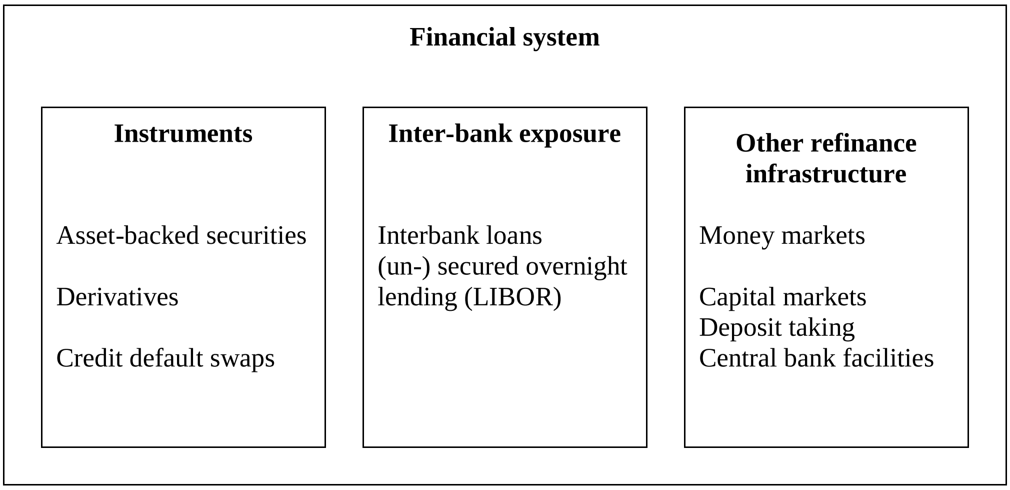
According to Shleifer and Vishny (2011) “fire sales” are:

> “[…] a forced sale of an asset at a dislocated price. A sale is forced in the sense that the seller cannot wait to raise cash, usually because he owes that cash to someone else. The price is dislocated because the highest potential bidders are typically involve in a similar activity as the seller, and are therefore themselves in a similar financial position. Rather than bidding for the asset, they might be selling similar assets themselves” (Shleifer and Vishny, 2011, p.30).

Further evidence to the validity of this definition is given by some examples of the crisis. The International Monetary Fund (2008) finds that in the USA between April and October 2008 the prices for Asset Backed Securities (ABS) declined by 20 per cent for a total of outstanding ABS worth US$ 1,100 billion with mark-to-market losses of US$ 210 billion. For the total outstanding US$ 400bn ABS collateralised debt obligations (ABS CDOs) mark-to-market losses were estimated to 60 to 70 per cent. The majority of these impairments were borne by banks with losses of approximately US$ 100 billion to US$ 110 billion for ABS and US$ 145 billion to US$ 160 billion for ABS CDOs.

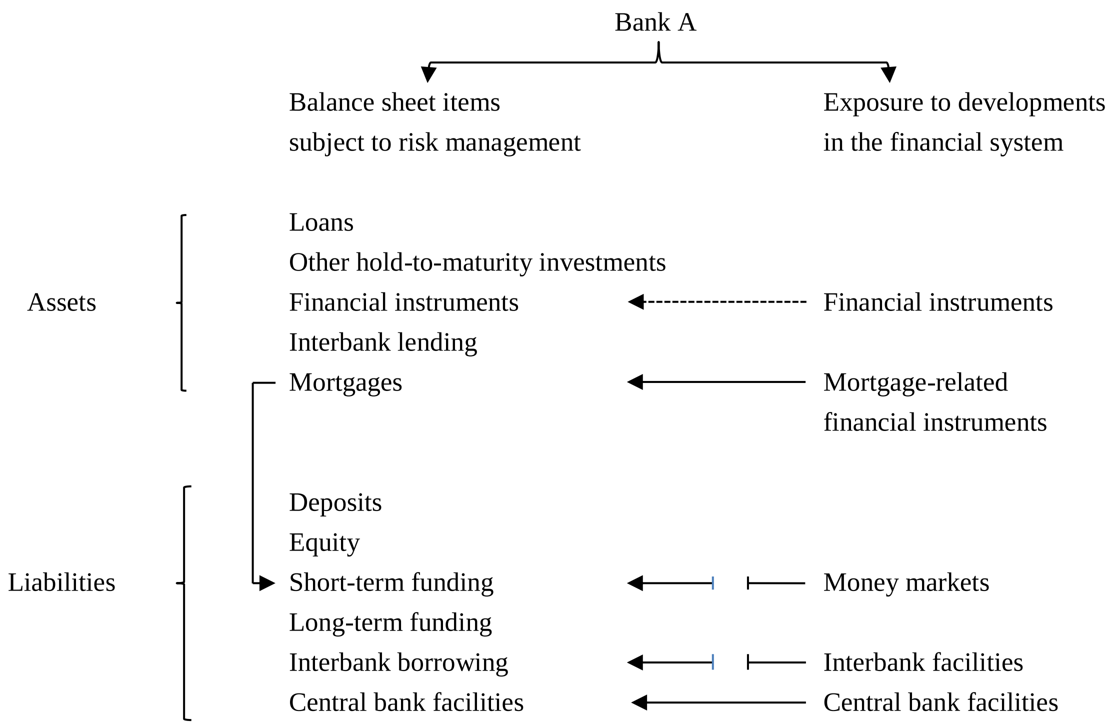
The popularity of mortgage-backed securities, and derivatives thereof, maintained for a couple of years but quickly turned into the other extreme, a complete drying up of the markets for those investments. The financial markets for securities with mortgages as underlying assets turned into what among some economists is known as a “market for lemons”, which was coined by Akerlof (1970). In the “absence of a mechanism for quality certifications” (Hellwig, 2008, p. 9) buyers cannot estimate the quality of the good on offer, e.g. creditworthiness. Therefore they discount the offer price to the known average quality in the market. The result of this adverse selection is that high quality goods are not sold, the average quality in the remaining market declines, and so does the average price. At the end of this spiral stands a complete market break down. Despite the existing preferences for the good, market participants do not trade. Figure 2.3 gives a simple map of the financial system for the purpose of this chapter.

Figure 2.3: A simple map of the financial system. Source: Own illustration.



The mortgage securitisation that is subject of the preceding sections of this chapter can be found on the left hand side as “asset-backed securities” as financial instruments available within the financial system. The defaults on mortgages led to the U.S. sub-prime crisis. However, the global financial crisis was further fuelled by the consequential credit crunch, i.e. the tightening funding opportunities in rest of the financial system. On the one hand, other banks were reluctant to lend to their peers via the interbank lending facilities as indicated by soaring LIBOR rates, see Figure 2.2, above. On the other hand, funding through the money markets became increasingly difficult, too, and central bank facilities had to be made more available at regulators’ decree. Furthermore Figure 2.4 below illustrates the effects of the financial system, which is depicted in Figure 2.3 above, on a bank A.

Figure 2.4: Interconnectedness of a bank to the financial system. Source: Own illustration.



The balance sheet items of bank A are listed on the left hand side and further separated by belonging to either assets or liabilities. The items are listed for the sake of readability and not by rank of liquidity. The right hand side reflects the simplified financial system.

Suppose bank A has a substantial investment in financial instruments of a certain kind, see dashed arrow. If this kind of instrument collapses bank A is directly exposed to price corrections and suffers losses. If bank A's capital is not enough to absorb the losses, bankruptcy occurs.

Brunnermeier and Pedersen (2009) distinguish between funding liquidity and market liquidity. First, institutions that rely on short-term funding must roll over their debt at a high frequency. To do so, they raise debt by borrowing against specific assets in their own portfolio, i.e. secured borrowing. This scenario indicated with the first solid arrow below the dashed arrow. Bank A is indirectly exposed to developments in the financial system. Mortgage-related financial instruments – e.g. sub-prime mortgage-backed securities – default on a large scale but bank A has no investment in such instruments. However, bank A needs to roll over its short-term debt and has frequently benefited from secured borrowing in money markets in the past. Its mortgages held on its balance sheet served as collateral for borrowing, see solid arrow from "Mortgages" to "Short-term funding".

However, in the extreme case lenders in the money markets can refuse to lend against mortgages in general, or at an increased risk premium – indicated with the disconnected arrow –, because of a panic about any mortgage-related bad news. The interbank facilities are alternative funding sources but are likely to be affected by adverse developments in the financial system, too, as indicated by the second disconnected arrow. Banks are less willing to lend on an unsecured basis. Secured lending is especially distressed if the collateral that is usually lent against is of a similar kind of the trigger event that caused the shock. Here mortgages in general were refused because of the large scale defaults in the sub-prime tranches of the mortgage market. Consequently, funding liquidity decreased steeply.

Second, as an alternative to this secured borrowing, the very same assets can be sold to raise liquidity, but this depends on the market liquidity. Selling assets is only possible if the markets for the particular assets are functioning. Different degrees of market liquidity are discussed in Kyle (1985). The integrity of market liquidity is negatively affected if a sufficiently high number of traders sell a particular kind of asset at the same time and drive down the price of that asset. This can be due to fire sales as defined above when similar firms decide independently from each other to sell the assets, i.e. bad timing; smaller firms mimicking one big firm to compensate for information asymmetries; or also collusive behaviour.

The last remaining funding source for banks that are directly or indirectly affected by the shock is the central bank, see bottom arrow. Therefore the central bank plays the role of the lender of last resort (Kay, 2010). The various extensions of central bank lending facilities and revisions of accepted collateral are listed at the beginning of this chapter and do not need to be repeated here.

Northern Rock suffered from this development. Mortgages from the USA defaulted on a large scale and consequently the asset backed securities based these mortgages did not receive payments, but the following decline in demand went beyond U.S. domestic mortgage-backed securities. More generally, most of these securities with the word “mortgage” written on them were affected. To continue the analogy of the market for lemons from a few paragraphs before, there could still have been a preference for mortgage-related securities but high quality could not be fully distinguished from low or sub-prime quality. At the end of the chain of securitisation, markets faced the simple realisation that nobody knew or cared about which mortgage-related securities were affected and which were not. To show this, in his testimony to the HM Treasury Committee’s report on the bankruptcy of Northern Rock, Mr. Applegarth, then Chief Executive of Northern Rock, clarified that the high credit quality of assets the bank had held was believed to assure access to liquidity in the financial markets. However, the bank could not borrow against their mainly UK residential mortgages. In case of tightening refunding conditions in the financial markets Northern Rock's chairman, Mr. Ridley, believed that its "low-risk book would remain easier to fund than sub-prime mortgages" (24 January 2008a ,HC 56-II Q 402 Ev48). This "flight to quality" (24 January 2008, HC 56-I para 24) did not occur. After it became clear that Northern Rock was facing liquidity problems ways of using the Bank of England's facilities were discussed, even though the bank was reluctant to use such assistance. Instead, the central bank assistance served as a backstop, if the market environment continued to falter. Mr. Applegarth concluded that: "[i]ronically, it was the announcement and the leaking of the backstop that caused the retail run and it was the retail run that reduced our liquidity" (24 January 2008a, HC 56-II Q 529 Ev48). Northern Rock was hit by a double run: First, the financial system refused to finance a certain kind of asset. Second, the depositors started a run because of news of financial difficulties.

On a global level, in order to protect themselves from defaulting investments in money market funds, financial institutions withdrew their money. This run on money market funds was stopped by the U.S. Treasury's intervention (Financial Crisis Inquiry Commission, 2011). It offered a deposit-protection scheme guaranteed by the government, i.e. tax payers' money. Generally speaking, reassuring banks that money market funds as refinancing source are secured would reassure the public that their deposits are safe, hence decreasing the risk of a bank run for withdrawing deposits. Yet, this was too late for several banks were not exposed in any way to mortgage-related securities, but on the other hand relied on funding by money markets.

An alternative explanation to market panics can be seen in the *de facto* connection of the sponsoring banks with SPVs, compare Figure 2.1 again. The banks first did not suffer from adverse funding conditions directly. However, they had to move the assets held by the vehicles back to their books and consequently value corrections hit their loss-absorbing capital cushions. This was eventually recognised directly by the financial markets.

In conclusion, the following picture of systemic risk appears: Direct links to the default risk of an asset class, such as credit risk of mortgages, are borne by the issuing financial institution. Financial innovation in the field securitisation added further elements to the chain of this exposure. With each link the "distance" between the source of risk and the end investor increased; first, literally in the case of European banks buying U.S. sub-prime mortgage-backed securities, and, secondly, banks kept distance to the composition and performance of these assets in the believe that the quality of risks were certified by credit rating agencies and the credit enhancements would abate possible defaults anyway.

2.5 Emergence of macro-prudential regulation

The previous sections analysed what led to the crisis of 2008. This section takes a general perspective on marrying the micro and macro aspects of the new framework to regulate banks and gives crucial definitions for “systemic risk”, “banks”, and “macro-prudence” that are relevant for the following chapters.

In the aftermath of the crisis of 2008 the new regulatory paradigm and consequently answering what macro-prudential tools to use, depends on the fundamental question for policy makers and regulatory agencies whether to “lean or clean” imbalances. An indicator for imbalance is when the growth of the financial sector is larger than the growth of the real economy (BCBS, 2011; Kim, 2011).

The term “macro-prudence” is obscure and hence subject to different interpretation, Clement (2010) gives an account of the origins and the evolution of this term. As of the current post-2008 Crisis discussion of making “macro-prudence” a pillar of any financial regulation framework, the term dates back to a Bank of England led working group chaired by Alexandre Lamfalussy from 1979. Then, concerns about the international financial system, and its stability, were raised in the context of the pace of globalisation with rising oil prices and implications for international bank lending. Nevertheless the group’s original definition identifies the exact same issues that the crisis of 2008 has once again revealed:

> “Prudential measures are primarily concerned with sound banking practice and the protection of depositors at the level of the individual bank. Much work has been done in this area – which could be described as the ‘micro-prudential’ aspect of banking supervision. […] However, this micro-prudential aspect may need to be matched by prudential considerations with a wider perspective. This ‘macro-prudential’ approach considers problems that bear upon the market as a whole as distinct from an individual bank, and which may not be obvious at the micro-prudential level” (quoted and cited in Clement, 2010, p. 61).

Especially the last sentence underscores that the stability of a system is not necessarily determined by the sum of all its elements. Even if all financial institutions operate profitably, this does not mean that the system is in good health. Borio (2003) defines macro-prudence by comparing it to micro-prudence among five criterions. What is prudent on a micro-level, i.e. at an individual firm level, is easy to comprehend and enables one to understand how prudence could be applied on a macro-level. First, the proximate objective of being micro-prudent is to limit the distress of an individual institution; macro-prudence aims at limiting system-wide distress. Second, the ultimate objective of micro-prudence is consumer protection, i.e. depositors, but macro-prudence aims at avoiding economic output costs. There is a critical difference: For the macro-prudential aim of limiting the costs to economic output, for example gross domestic product, the micro-prudential aim of depositor protection is not a necessity. Borio illustrates the different approaches with the example of a portfolio of securities: The "macroprudential [sic!] approach would then care about the tail losses on the portfolio as a whole, its microprudential [sic!] counterpart would care *equally* [sic!] about the tail losses on *each* [sic!] of the component securities" (Borio, 2003, p. 2). Put differently, a micro-prudential approach to financial regulation is concerned about the stability of each and every financial institution but the individual stability is not crucial for a macro-prudential approach as long as it does not threat the stability of the whole system. Third, this consequently implies that risk is endogenous on the macro-prudential level but individual institutions face risks mostly as exogenous. Hence, fourth, common exposures across institutions are not relevant for the individual institutions when one takes a micro-prudential approach but is important on the macro-prudential view. Fifth, this leads to implications for introducing prudential controls, i.e. regulation. Under the micro-prudential approach a peer group assessment can be used. This simply means comparing a financial institution to other, similar institutions and look how it compares to the rest of the sector. The macro-prudential approach reverses this bottom-up principle and analyses top-down. A peer group assessment is still in use but additional aspects such as concentration of exposure among these institutions – that per definition are not captured in the micro-prudential approach – are included.

The next sections of this chapter narrow down the vast group of "financial institutions" to banks – as deposit-taking institutions that are subject to macro-prudential regulation in particular –, locate the interim results and further analysis in the literature, and define "systemic risk", which is exactly that crucial element that is not obvious at the micro-prudential level, but on the macro-prudential level.

In anticipation of the next chapter where the structure of the new macro-prudential regulatory agencies is discussed, the regulatory agencies can be tasked with "leaning" against excessive credit growth that leads to asset bubbles and in the worst case to a full crisis. A collapse of such is the initial external shock to the financial system, fire sales further fuel asset spirals, and a cascade runs through the financial system with the consequence that the whole system becomes unstable. Various tools aim to help lean against this developments such as sectoral capital requirements as will be examined in chapter 4. Kashyap and Stein (2004) contribute early work on making banks' capital requirements dependent on the state of the economy to lean against procyclicality. Yet new macro-prudential tools are more specific. For example excessive growth of the sector for residential mortgages, as opposed to the general state of the economy, can be countered directly by increasing interest rates for originating residential mortgages, so that banks give out fewer mortgages. Before the crisis a monetary policy response could have been to increase the interest rate that applies to the whole economy rather than one particular sector. This risks constricting growth in other sectors of the real economy. Yet, the difficulty is to determine whether this persistent gap is excessive (Shin, 2011).

Alternatively regulatory agencies can be tasked with "cleaning". This puts regulatory action after the imbalances led to a shock. So after a shock regulatory agencies must use their mandate and tools to contain the damages from spreading. This resembles the cleaning up programmes that could be observed during the crisis. Yet, the critique that the new policy responses are again "piecemeal" (International Monetary Fund, 2009, p. 6) must be avoided. A lot of precious time can be saved when regulatory agencies have an array of specific tools at their disposal in order to intervene and clean specific pivotal points in the financial system. For example capital minimum requirements can be temporarily increased to bolster banks' loss-absorbency, and additional central bank lending facilities can be temporarily made available to enhance liquidity for troubled assets.

Macro-prudential financial regulation is a holistic approach to first address the build-up of imbalances in the first place; second, defence against downswings of disruptions; and third, identifying risk concentration and interdependencies in the financial system (International Monetary Fund, 2011). Obviously the first two items suggests leaning and cleaning, rather than one or the other apporach.

This chapter identifies that the build-up of imbalances start at the micro level with investment decisions of banks. Much is accomplished if imbalances in the form of excessive asset growth are countered.

However the structure of the financial system itself is a concern to the stability of the system too. Even if this systemic risk is not the consequence of unsustainable risk macro-prudential policy must find ways to save the financial system from its inherent instabilities. Disruptions in the form of external shocks are amplified within the system and downswings can be worse than expected.

The identification of interconnectedness and quantification of systemic risk is a crucial part of macro-prudential regulation. Chapter 5 goes into more detail with an empirical analysis of systemic risk in the European banking sector, covering data from the year 2000 on, so including crisis and non-crisis times.

Beside the new regulations that are considered the institutional arrangements of regulatory agencies is an important challenge too (Kim, 2011). Since the crisis was global, so must be the policy response. Yet, the proper supervision of banks is subject to national law. The current regulatory authorities tasked with supervising banks need to be revised in their scope and equipped with new legal mandates. Consequently this also touches challenges such as the accountability of the regulatory agencies and a new cultural approach within these authorities. This is subject of chapter 3.

However, there are difficulties in defining the scope of macro-prudential financial regulation. For example according to the Section 112(a)(1)(A) of the Dodd-Frank Wall Street Reform and Consumer Protection Act in the USA (henceforth Dodd-Frank Act) the newly found Financial Stability Oversight Council is tasked with identifying:

> "risks to the *financial stability* of the United States that could arise from the material financial distress or failure, or ongoing activities, of large, interconnected bank holding companies or nonbank financial companies, or that could arise outside the financial services marketplace" (Emphasis added).

This leaves space for interpretation and applicability of "financial stability". On the one hand one problem of such a task of regulatory agencies is that too vague a definition could blur the regulatory agency's view on what they are expected to deliver to the broader public. Perhaps the agenda within the agency is not clear enough. Regulatory staff need explicit mandates that clarify their responsibilities and scope for their own work (Domanski and Ng, 2011) On the other hand such a definition enables the agency to be flexible to address urgent issues without any legal constraints that need to be addressed first, otherwise losing precious time.

Reinforcing financial stability through macro-prudence can be interpreted as "leaning against" the financial cycle, so that asset bubbles are avoided in the first place (Bank of England, 2009; Borio, 2003 and 2010) – the theory behind asset bubbles is depicted in section 2.5.2 below. A second interpretation is that macro-prudence should aim at specific problems that naturally occur in times of system wide distress (Hanson *et al.*, 2011). Among them are the mechanisms like fire sales and consequent credit crunches, i.e. disruption of lending to the real economy also known as dis-intermediation. So there are two interpretations for macro-prudential regulation: broad and specific interventions. However, a regulatory agency's sound judgement whether to intervene necessitates evidence that the financial stability is at stake, i.e. systemic risk is gathering momentum. Identifying systemic risk *ex ante* is the top item on the agenda for it is difficult to quantify.

Furthermore the research scope of this PhD thesis is limited to banks. The previous sections addressed issues arising from the banking sector exclusively across national boundaries. Of course banks are only one kind of financial institutions of several in the global financial markets – pension funds, hedge funds, etc. are non-bank financial companies. The next section gives a further definition of what a "bank" is and gives arguments why these institutions in particular should be regulated.

2.5.1 Banks are key financial institutions in financial crises

This sub-section narrows down the scope of research of this thesis to "banks", that are defined here. The terms "financial institution" and "bank" are used throughout this PhD thesis. In anticipation of the remaining chapters, a bank is defined as a deposit-taking financial institution. They perform what the financial literature calls "liquidity transformation" of liquid demand deposits to fund illiquid loans and other investments. A financial position such as a deposit at a bank is "liquid" when the banks' customers, the depositors, can withdraw the deposit. On the other hand, a financial position such as a mortgage is a long-term commitment of the mortgage taker and a long-term investment of the mortgage issuer. From the issuer's position it is difficult and legally not usually possible to call the full amount of the mortgage back immediately, hence it is illiquid. In this context by accepting deposits the banks "produce money-like debt" (Admati and Hellwig, 2013 p. 155) that can be granted as loans.

In the UK the term "bank" is not explicitly defined in the Financial Services and Markets Act 2000 and its amendments by the Financial Services Act 2012. Rather than an institutional approach to defining what a bank is, UK policy makers define a bank by the definition of the functions exercised by certain financial institutions. So a bank is a regulated subject under the Act if it performs a "regulated activity". In the rulebook of the Prudential Regulation

Authority, the post-crisis UK regulatory agency, article 5 of the Regulated Activities Order 2001 SI2001/544 identifies “accepting deposits” as a regulated activity.

In the USA the definition of a bank is written down in 26 U.S. Code § 581. A firm has to fulfil three criteria to be considered a “bank”: First, it must be a firm that does business under the laws of the United States or of any state. Second, receiving deposits and making loans are substantial parts of this business. Third, the firm must be subject by law to supervision and examination by U.S. authorities that have supervision over banking institutions.

It is clear to see how financial intermediation plays a fundamental role in financing the economy. The two key benefits are deposit-taking and the payment system. Both are fundamentally linked to each other. Traditionally the “checking accounts in which demand deposits are kept allow people to receive and make payments through checks, bank transfers, or the use of debit cards and credit cards” (Admati and Hellwig, 2013, p. 49). Those citizens and firms who have excess money deposit it at a bank and those citizens and firms who need it can get a loan from the bank. However, the bank must manage the maturity mismatch between its investments and debts in form of deposits. The liquidity of deposits is by no means guaranteed but highly sensitive to the bank’s investments. Pozsar *et al*. (2012) warn that credit creation with this intermediation is inherently fragile and prone to bank runs. This continuous threat is the justification for banking regulation (Freixas and Rochet, 2008).

Banks must decide what loans are sound investments in order to secure long-term profitability and hence reassure depositors about the liquidity of their deposits. Risk management departments within banks assess the creditworthiness of potential loans and monitor them after their issuance better than individuals could. They benefit from economies of scale in collecting and assessing information about borrowers’ creditworthiness. Given this expertise banks have an informational advantage.

Banks have access to capital markets providing funds with long maturity and access to money markets providing funds at shorter maturity. Also banks lend excess funds to each other overnight. This can occur secured, i.e. funds in exchange for collateral like government bonds, or unsecured, i.e. the funds are not lent against collateral. A disruption of this financial intermediation performed by banks can be the cause of economic crises or can exacerbate distress towards a crisis. Hence this pivot in the economy must be protected.

2.5.2 Locating the interim results and analysis in the literature

This sub-section connects the results from the previous sections on securitisation and highlights the economic theory background that made the U.S. sub-prime crisis breeding ground for the global financial crisis of 2008. The shift towards the macro-prudential framework for financial regulation also challenges the policy makers in charge to reconsider their own beliefs. Turner (2011) emphasises the need for:

> "radical challenges to dominant economic theory. Was this crisis, as some have argued, a crisis not just of specific institutions and regulations, nor even just a crisis of markets in general, but also of an entire economic theory? And if so has that theory been appropriately de-throned?" (Turner, 2011, p. 2).

The term "systemic fragility" was coined by Minsky (1977). What is known in the macroeconomic literature as "Minsky moments" are sudden collapses of asset values that are the direct consequence of business cycles within the economy. It is important to understand that this potential for a crisis is endogenous and not simply a short term deviation from a growth path. Because of the recent crisis the debate about the endogeneity of boom-bust cycles in the economy found attention not only among academics but also among central bankers such as Janet Yellen, succeeding Ben Bernanke as the Chair of the Federal Reserve in 2014. She points to the applicability of Minsky's financial instability hypothesis to the crisis. So, "when optimism is high and ample funds are available for investment, investors tend to mitigate from the safe hedge end of the Minsky spectrum to the risky speculative and Ponzi end" (Yellen, 2009, p. 3).

There are three stages of financial fragility developed in Minsky's work (Minsky, 1986) when economic agents, for example private investors and households, are indebted. First, "hedge finance" describes that economic agents and firms can repay their debt via usual economic activities such as income-generating labour and company earnings, respectively. Holding cash reserves and the ability to liquidate assets serve as buffers in the case of an unexpected decline in income or increase in cash outflow.

The second stage is "speculative finance". Cash reserves and the liquidity of assets are not enough to counter expenses for liabilities. Hence, borrowing funds is necessary. Typically, banks as financial intermediaries are based on a business model to constantly borrow funds to repay claims of their depositors.

The third stage is “Ponzi finance”. Cash reserves and liquidating assets are insufficient to pay the debt. At this stage, in order to meet liability commitments, economic agents depend and rely on growing asset prices that can be liquidated in the future. The individual economic agent is now financially fragile. Alternatively, economic agents can avoid their fragility becoming instability if they can rollover their debt obligations. This Ponzi stage requires that enough funding opportunities are available in the economy in order not to collapse. To draw a preliminary conclusion, recall the lax mortgage business that made mortgages available to sub-prime borrowers. The mortgages were subsequently financed by international financial markets with plenty of funds. The originate-to-distribute model was bound to collapse for the mortgages were never to be paid back in full.

Tymoigne (2010) hypothesizes that in capitalist economies Minsky moment like boom-bust-cycles are a natural by-product of economic activities of economic agents. This stands in stark contrast to the pre-2008 crisis prevailing view that the business cycle has been tamed. For example in 2004 Ben Bernanke proclaimed the self-understanding of central banking as merely further promoting the long lasting era of low macroeconomic volatility, known as “Great Moderation” (Blanchard and Simon, 2001). Since the 1980s the observed low volatility of economic output in advanced industrial economies has declined (Blanchard and Simon, 2001), meaning that economic output has been growing smoothly.

Three possible effects might explain this observation, see Bernanke (2004). First, structural changes such as the use of sophisticated information technology allowed firms to utilise communication in order to make their operations more effective. Furthermore, deregulation has allowed financial market integration and opened international capital flow. Second, “macroeconomic policies have helped moderate the variability of output as well” (Bernanke, 2004). The third effect, according to Bernanke, that explains the economic stability is simply good luck, and he refers to empirical studies in support of a “good luck hypothesis” (see for example Ahmed *et al*., 2002; Stock and Watson, 2003)

However, an increase in financial fragility has its roots in ostensibly economic good times. Risks accumulate during optimistic times and go unnoticed – or plainly ignored. This is also known as the “volatility paradox” (Adrian and Brunnermeier, 2011). Hence, researchers face the challenge to choose the correct indicators to detect fragility when concerns generally find little attention in the markets.

A preliminary conclusion is that it is essential for regulators to address unsustainable financial practices. The business practice in the financial sector needs to be in order first. For example, the global financial crisis of 2008 was sparked by the crash of the U.S. housing market bubble that was fuelled by over-optimistic mortgage borrowers and lenders. Initial mortgage payments were advertised at historically low “teaser rates” combined with little to no equity contribution to the house purchase by the borrower. In the case of payment difficulties of the mortgage borrower, the mortgaged house itself served as collateral. As long as the national house price index in the USA constantly went up, the system worked. The building up and crash of the U.S. housing market turned out to suffer from its inherent fragility and was bound to collapse. This is a common property shared with a Ponzi scheme. However one cannot speak of a deliberate fraudulent intention of the mortgage issuer, which is also the definition of a Ponzi scheme.

2.5.3 Systemic risk becomes a permanent concern

This sub-section defines “systemic risk”. A macroeconomic perspective must be in place since micro-prudential principles alone cannot reinforce the stability of the financial system (Shirakawa, 2009). The term “systemic vulnerability” was coined by Cline (1984) in the context of the Latin American crisis of the 1970s. The vulnerability of the whole system is inherent rather than a temporarily occurring problem. Hence systemic risk emanates from the single bank permanently but differently strong across banks and across time.

The term “systemic risk” was first used also in the context of the Latin American sovereign debt crisis of the 1980s (Cline, 1984). A universally applicable definition of systemic risk is given in Zigrand (2014):

> “Systemic risk is the risk of an event – labelled a systemic event – occurring in a given system […] that leads, at least temporarily, to an altered and damaged transitional ‘system’ […] whose proper functioning is impeded. In the extreme, the structure of the system itself is damaged and the system no longer functioning.” (Zigrand, 2014, p. 32):

In his financial markets-related definition of systemic risk, Mishkin (1995) points to the likelihood of a “usually unexpected […] event that disrupts information in financial markets” (p. 32). In the context of a global financial system, a definition by Federal Reserve Governor Tarullo (2009) is that:

> “[f]inancial institutions are systemically important if the failure of the firm to meet its obligations to creditors and customers would have significant adverse consequences for the financial system and the broader economy.”

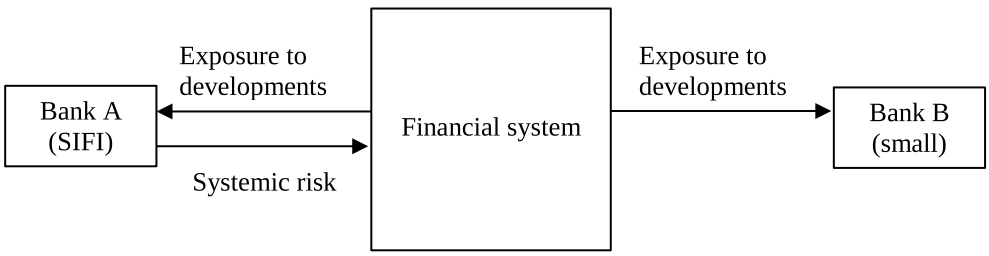
The Group of Ten (2001) further reduces this risk's definition to a state where:

> "[…] an event will trigger a loss of […] confidence in, and attendant increases in uncertainly about, a *substantial portion* of the financial system that is serious enough to quite probably have significant adverse effects on the real economy" (p. 126) (Emphasis added).

Acharya *et al*. (2012) reinforce the Group's point of view by noting that Tarullo's definition lacks the crucial insight that systemic risk is not exclusively indicated by a single firm's failure *per se*. If a financial institution cannot financially intermediate anymore – whether too low capital or a total default – the competitors will simply take over the business opportunities. Hence the consolidation of the group of suppliers of credit is in itself not problematic and not systemic (Goodhart, 1996). Instead, if the aggregated financial intermediation is disrupted, then systemic risk is of an economy-wide concern.

As a conclusion, the stability of a financial system can be undermined by either an exogenous shock and by the endogeneity of the financial system. The latter did not receive due attention in pre-crisis financial regulation. Both factors work together and exacerbate the damage to stability. Figure 2.5 illustrates banks' exposure to the financial system and systemic risk that stems from the banks.

Figure 2.5: Systemic risk and financial system exposure. Source: Own illustration.



All banks are exposed to developments in the rest of the financial system, including changes in macroeconomic factors as depicted in Figure 2.3 and 2.4 in section 2.4.5 above. For example, bank B is a bank that operates in a geographically narrow, local market. Its distress does not affect the stability of the financial system. Bank A is a systemically important financial institution (SIFI). This is either by sheer size or interconnectedness to the rest of the financial system, including other banks. If bank A gets into financial distress this could have negative consequences to other banks. Macro-prudential policy makers must consider that an initial exogenous shock that brings bank B into distress can cause systemic risk that feeds back into the financial system and gathers momentum. After the exogenous shock an endogenous disruption follows, so that the stability of the financial system is at stake.

For example, a sudden decline in macroeconomic factors can drive up the default rate on mortgages, see the sub-prime crisis. Some financial institutions are engaged in such business and enter financial distress. Because other financial institutions invested in those mortgage issuing firms directly or are exposed to the dry up of mortgage-backed securities, see above, the initial shock is propagated in the financial system. In case deposit-taking banks are a link in this chain of institutions and markets, the negative effects are more severe. Depositors run on a bank that is directly exposed to the exogenous shock. If another bank's depositors lose confidence in their bank – even despite deposit protection being in place (Iyer and Puri, 2008) –, which is not directly exposed to the shock, the observed bank run might trigger a further panic and runs on other banks.

Hendricks (2009) suggests that systemic crises have three distinct sources that each can cause sufficiently large disruptions and usually crises are combinations of these. First, the classic bank run attracts the public's attention through media and introduces a momentum. If bank depositors lose, for whatever reasons, confidence in their bank, they withdraw their deposits. In order to pay out a substantial number of depositors at the same time, the bank is coerced to liquidate profitable investments to raise the physical funds that are paid to the depositors.

Second, a full-grown systemic crisis can be caused by a financial market collapse. A certain asset class is exposed to soaring prices within a relatively short time and is soon perceived to be a bubble. When the bubble busts and the cumulative losses are "deep and widespread enough" (Hendricks, 2009, p. 3) markets will be concerned about additional losses but are uncertain as to where exactly. Furthermore, the perception of losses is state-dependent, too. During a crisis, markets might give more relevance to the losses of certain institutions that might have been ignored in the normal state in the past. This state-dependence is subject of the empirical research on systemic risk in chapter 5. The case of Northern Rock demonstrates that this shift of perception is also applicable to markets for certain kinds of assets like mortgages.

Third, an infrastructure collapse undermines the integrity of market mechanisms themselves. The result is a disruption of trading and liquidity, as exemplified with Northern Rock's struggle.

2.6 Conclusion and defining the research questions

The global financial crisis of 2008 was sparked by the crash of the U.S. housing market bubble that was fuelled by over-optimistic mortgage borrowers and lenders. Initial mortgage payments were advertised at historically low “teaser rates” combined with little to no equity contribution to the house purchase by the borrower. In the case of payment difficulties of the mortgage borrower, the mortgaged house itself served as collateral. However, this condition created an inherent instability. As long as the national house price index in the USA constantly went up, the system worked. Even though there was no deliberate large scale fraud, like the Ponzi scheme is defined, the building up and eventual crash of the U.S. housing market demonstrated that this system was not based on a sustainable business model and, due to its inherent instability, value corrections fuelled a downward spiral.

The credit risk of mortgages was converted into market risk of now mortgage-backed securities. While the returns remained at the issuing banks, the risks were distributed to the global financial system but were not encountered by enough risk-weighted regulatory capital.

Next, the initial shock was the large scale default in the sub-prime mortgage business and was introduced to the global financial system through asset-backed securities. What originally was a “pipeline risk” (Brunnermeier, 2009, p. 82) to the originating bank turned out to create systemic risk. Furthermore, even those banks that were not involved in the sub-prime business faced repercussions as the financial system, of which they were part of, collapsed.

As a direct consequence of the shock to mortgage-related securities banks were limited to roll over their short term debt and saw funding liquidity deteriorating because money markets were reluctant to lend against mortgages in general. Furthermore, market liquidity for mortgages deteriorated too, because banks were quick to fire-sale mortgages to raise funds. Thus, the shock in the U.S. mortgage market was introduced to global finance through securities serving as a conduit. This was further amplified by propagation channels such as money markets that are a fundamental part of the market structure itself.

With financial institutions like banks this problem is more severe because they are all part of a financial system and are exposed to negative externalities that come with belonging to a network. Banks can also fail when they are not directly tied to one another but also, indirectly, just happen to be in proximity.

Making sustainable investment decisions and the interconnectedness of the financial system, are the foundation for financial stability. They are now translated to the two core research questions in more general terms. This PhD thesis' main research question is whether the particular regulatory technique discussed in the chapters can fulfil the new regulatory objective to maintain financial stability. This is further separated into two more specific research questions:

- Does the subject which is analysed in this chapter, address the regulated institutions' incentives so that they abstain from taking unsustainable risks that can cause a systemic crisis?
- If yet systemic risk emerges, does the subject, which is analysed in this chapter, able to limit its potential for further damages?

The first question aims at the creation of risks on the individual bank level, i.e. micro-level. For example, if banks would have known that the originate-to-distribute business model allowed for distributing the credit risk of low quality assets to the global financial markets, would they have abstained from it? Would other non-originating banks have abstained from investing in such securities? Ideally, the financial system is made more stable if banks are diligent and neither excessively create nor invest in such financial instruments. Macro-prudence should first be exercised where risks are created in the first place.

The second question considers the fact that even if the participants in the financial system are diligent it is the endogeneity of the system's structure that can cause instabilities and crises. The interconnectedness of the global financial system itself is a source of systemic risk. Hence the respective chapters also analyse whether the chapter's subject can also put a stop to the momentum of systemic risk.

The state of the global financial markets was defined by a high degree of interconnectedness of markets and "global player" institutions that, during the peak of the crisis when governments made available bail out provisions, were deemed "too big to fail". Originally, the "too big to fail" doctrine described institutions that enjoy certain benefits because of their absolute size and presence in global markets (Turner Review, 2009). In the April 2006 report on global financial stability, the International Monetary Fund emphasised the benefits of financial innovation – including securitisation – and:

> "[…] the emergence of numerous, and often very large, institutional investors and the rapid growth of credit risk transfer instruments have enabled banks to manage their credit risk more actively and to outsource the warehousing of credit risk to a diverse range of investors. A wider dispersion of credit risk has 'derisked' [sic!] the banking

sector, which still occupies a strategically important role in the economy, in part because of its role in the payments system" (International Monetary Fund, 2006. p. 1).

The key fallacy in the above citation is the de-risking of the banking sector which is argued in the analysis in this chapter. In its regulatory response, the UK Financial Services Authority also hints to the fundamental theoretical assumptions that led the financial system and regulatory agencies alike (Turner Review, 2009). Brunnermeier *et al*. (2009) point out that the markets' and financial regulators' perception of the stability of banks and other institutions, and the system are vulnerable to the fallacy of composition that "arises when one infers that something is true for the whole from the fact that it is true for each of the individual components of the whole" (p. 75).

In conclusion, the crisis has shown that banks' actions to increase profitability seen in isolation are perfectly comprehensible. However, the stability of the financial system is not solely determined by the aggregate of the soundness of all firm-level actions. The full dimension of consequences of an institution's activities to the rest of the economy is by construction not properly reflected in an isolated analysis (Brunnermeier *et al*., 2009). This assessment must be extended with taking interdependencies between the institution and rest of the financial system into account. These interdependencies are endogenous risks to the stability of the financial system. Thus, the regulatory agencies must employ a macro-prudential approach, too. How this approach can be implemented is the subject of the next chapters.

3 Towards a macro-prudential regulatory framework

This chapter gives a brief introduction tho the regulation of markets and industries in general. Next follows a discussion how to organise a financial regulatory agency before the concrete plans for a macro-prudential regulatory framework is implemented in the UK, USA, and EU.

3.1 Introduction

The previous chapter identified that systemic risk is inherent in the financial system in the 21st century. The degree of interconnectedness of banks and different financial markets distinguishes the 2008 crisis from previous financial crises. Because of doubtful financial innovation the fundamental link of risk and return has eroded. Ill-aligned incentives, such as prioritising short term profitability over long-term sustainability (de Larosière Report, 2009) further accompanied the change. This is partly because of an economic environment that was perceived tranquil and partly because the innovations allowed for doubtful business practice, and lack of monitoring thereof. The shock in the U.S. sub-prime mortgage market destabilised the global financial system.

This chapter focuses on the framework of the new regulatory agencies to fulfil macro-prudential regulation. The macro-prudential framework comprises the architecture of the regulatory agencies and the regulations banks have to abide by. The newly found structures and the revised structures in the UK, USA, and EU serve as examples. Independent from the structure, the macro-prudential tools that can be used to achieve the regulatory objective of financial stability are the subject of the next chapter, i.e. systemic risk capital buffers on top of the revised minimum capital requirements.

Section 3.2 is an introduction to the rationale of regulation in general and implications for the choice of a regulatory architecture. Section 3.3 analyses whether macro-prudence should be addressed on a national or global level. The sections also trade off the advantages and disadvantages of having one regulatory agency in charge against having several specialised regulatory agencies. Next, section 3.4 analyses the particular challenges of creating a global regulatory framework. Section 3.5 exemplifies the different structures with the newly created and revised regulatory agencies in the UK, USA, and EU. Possible issues that come with the switch towards the macro-prudential paradigm are identified. Each of the three reformed frameworks are analysed according to first, the regulations they impose on the banks, and second, whether the change of the architecture of the respective regulatory agencies can deliver their macro-prudential task. Section 3.6 concludes.

The previous chapter analyses the nature of systemic risk and so helps further define what is means for a regulatory agency to be macro-prudend, i.e. addressing the building up of unsustainable risks and the propagation channels through which systemic risk can spread. The regulatory response needs to be analysed. As shown systemic risk requires a holistic approach that goes beyond imposing micro-level regulations. This approach is macro-prudential financial regulation. This chapter answers the questions whether the reforms of financial regulation underway, i.e. the regulations the regulated subjects have to abide by and restructuring of existing regulatory agencies, firstly incentivise the regulated subjects to conduct their business in accordance to promoting financial stability and secondly are appropriate to counter systemic risk as it materialises.

3.2 The rationales for and approaches to financial regulation

This section presents the rationale for regulation by giving some examples. Economic theory suggests three rationales for financial regulation (see representatively Davis, 1993; more general and application to other industries such as transportation and telecommunication, see Pera, 1989; Kahn, 1988): information asymmetries, negative externalities, and monopoly power. The latter is not as relevant for the purpose of this chapter as the other two and is excluded for the sake of brevity.

If one of these elements can be observed in the real word and the market forces cannot solve the problem at hand by themselves, there is a market failure and a regulatory intervention can be justified if it improves the situation. So, the Organisation for Economic Co-operation and Development (OECD) defines regulation according to their work as a “diverse set of instruments by which governments set requirements on enterprises and citizens” (OECD, 1997, p. 5). It further distinguishes three broad categories of regulations: First, economic regulations directly affect prices. Examples are controls in the form of caps and floors, competition, market entry barriers and market exit, innovation. The aim is to promote efficiency of markets. The government creates the law that stands at the fundamentals for the regulations. The enforcement can be carried out by different organisational institutions. Government-sponsored organisations, i.e. regulatory agencies, have the legal powers to create specific rules based on the law.

Second, social regulations help protect the public interest, including health, safety, environmental concerns, and social cohesion. The OECD recognises that social regulations can have unexpected economic effects and a sound analyses are required to derive a genuine need for regulations.

Third, administrative regulations are the administrative formalities to put policy into practice. Changing these regulations involve cutting ‘red tape’, i.e. simplifying those administrative regulations that are needed and eliminating those that are no longer needed. In contrast to the other two categories of regulations, here the daily work of regulatory agencies and their organisational structure is in the centre of attention. This is independent of the existence of an aim that regulations seek to achieve, whether fostering economic efficiency in a particular market or promoting health as a public interest.

For the purpose of this chapter economic aspects of institutions are in the focus. Particular interest is paid to “institutions as a special type of social structure with the potential to change agents, including changes to their purposes or preferences” (Hodgsons, 2006, p. 2). Here, “institutions’ are interpreted as regulations imposed on banks and regulatory agencies. The latter are organisations like central banks that are in charge of proposing regulations and supervising the banks. They consciously aim at changing the behaviour of a specific group of subjects by means of regulations.

Market failure is put at the centre of argumentation for economic regulation and intervention by those who are legally enabled to do so, e.g. central banks and regulatory agencies. A failure is associated with a loss of social welfare. Regulation aims at incentivising private decision-making to reach an output that maximises welfare.

The power of market forces to set incentives is a crucial point for this PhD thesis. The previous section analysed how U.S. banks’ incentives to give out sub-prime mortgages on a large scale were an unsustainable business. True, individuals seek to maximise their wealth according to what the environment provides them with. Record low interest rates fuelled the demand for mortgages, fostered by a housing-friendly policy in the USA, and amplified by securitisation of such mortgages. A constant re-evaluation of such political will must of course be in place, but this is not the subject of this research. Despite the political agenda to foster growth in certain sectors of the economy, the final decision whether to invest or not should rest with those who have to manage the credit risk, i.e. the issuing bank. Hence, despite the political agenda, the incentives to maintain sound economic reasoning must be maintained.

Addressing the issues is best made through economic regulation, especially market-based regulatory instruments. Market forces are more likely to be effective and efficient. A government involvement in banking is problematic, since the allocation of resources to investment opportunities with the highest possible returns – and its success is reflected in overall bank profitability – is not ensured. The government has a home bias (Cerutti and Claessens, 2014; De Haas and Van Horen, 2012) towards domestic lending, hence limiting financial cross-border integration. This would limit the bank to explore profitable lending opportunities abroad and disables the bank's ability to diversify its portfolio, hence decreasing its overall risk.

For example, the German state-owned Landesbanken suffered severely from the global financial crisis more than the private banks. In contrast to private banks, these Landesbanken by law serve a "public purpose" (Deeg, 1999). However, before the crisis these institutions gave themselves different business models and so there were ambitions to either become the world's largest financer of container ships, become the largest financial institution in eastern Europe, or compete with the global investment banking firms – all backed up by their close ties with the local governments and implicit guarantees (Papendick, 2009; Liikanen report, 2012). In the private sector profitability is the decision-making factor for each endeavour and put an early end to senior managers' strategy if it is not convincing. However, with state-owned banks like the Landesbanken, the simple ambition to expand regardless of long term profitability was at the core of decision-making and so they competed in complex global transactions that went well beyond their expertise (Schrooten, 2008).

However, private incentives in banking are not purely limited by long-term profitability considerations. There are explicit government guarantees in place in the form of deposit protection schemes and implicit guarantees to protect a struggling bank if it could otherwise destabilise the rest of the economy. This protection to some degree relaxes the constraints on bank managers: If the business strategy fails, the government, i.e. tax payer, covers the losses.

A government's command-and-control approach to regulation can introduce a prohibition on certain activities (Senden *et al*., 2015). Such a decision can be called effective, when the particular problem is solved. However, the prohibition of a whole activity, rather than one detail that was the cause for regulatory invention in the first place, is likely to be inefficient. The cost of such a prohibition stands in stark contrast to the benefit.

For example, suppose that the carbon dioxide emissions of a manufacturing industry are considered too high and this puts the public's health as a policy objective. A prohibition of pollution in the form of a cap on the industry's emissions translates into a permit for each firm to emit the same amount of carbondioxide. It is likely that the largest producers are driven out of business because they cannot avoid enough emissions, or can only do so by drastically reducing their production. Hence, competition in the industry is distorted which make the industry output more expensive to the consumers because of foregone economies of scale in the production. Instead, an effective and efficient solution would be to introduce an industry cap but allow the firms to trade their allowed emissions. Smaller firms can sell their excess permit volume, i.e. pollution right, to the larger firms that are likely to pollute above the industry average. This approach is called the market-based regulation. Harnessing market forces actively incentivised the economic agents to pursue a regulatory objective not because they see the utility for the broader public – this is the regulatory agency's view – but because of its own financial interest. This strategy is at the centre of argumentation in chapter 6 and especially in chapter 7. There CoCos are analysed and proposed as a macro-prudential tool to regulate banks by setting incentives.

In conclusion, in a competitive market the price for a particular good regulates the behaviour of producers and consumers and so determines the allocation of resources. Yet, the allocating-power of prices is not ensured at all times. For example a high volatility of prices drives the behaviour of market participants into unsteady directions. This can become a major concern that leads the way to a complete disruption of the market, i.e. a market failure.

The recent crisis, as shown in the previous chapter, was a crisis of externalities. In the most basic case an externality means that an economic agent is affected by the actions of other economic agents. During the crisis, individual bank were negatively affected by the economic activities of other banks and financial institutions in the form of worsening refinancing conditions, compare section 2.4.5 and figure 2.4 for how interconnectedness of the financial system enables negative externalities. However, if the price for a certain asset declines because the markets found a new price for it, it is not a negative externality on the books of a particular bank that has to mark the asset to the new lower market price. The decline must be rather rapid and sufficiently strong to start a self-amplifying spiral that leads to a series of bank bankruptcies (see, for example, Adrian and Shin, 2008; Brunnermeier and Pedersen, 2005; and Geneva Report, 2009). Only if the financial losses of such a spiral are not met in full by enough banks and their shareholders directly – hence internalised –, then social costs can occur. These externalities are the systemic risk of one bank to the rest of the banking system. An empirical analysis of this is subject of chapter 5.

3.2.1 Self-regulation approach

The previous section shows the rationale for regulation. Consequently after identifying the need for regulation, this sub-section shows how regulations can be introduced to achieve the desired objective. One approach is the self-regulation by the industry; the other is a government approach that involves an active role by the national legislator.

Self-regulation happens on the industry level in order to introduce a behavioural pattern that avoids the prisoner's dilemma every industry participant is exposed to. In short, and generally speaking, the dilemma describes the situation in which all market participants have the incentive to cheat in order to maximise their individual wealth to the detriment of the other participants. However, if all participants do so, the Also there is no mechanism to detect such behaviour or only at prohibitive costs (Tullock, 1985). Market participants still do co-operate if the framework of analysis is expanded to repeated co-operation where one's credibility is necessary to engage in further co-operation in the future. Hence, the simple fear of a loss of reputation is the foundation for markets' self-regulation (O'Driscoll and Hoskins, 2006) and avoiding the prisoner's dilemma. The integrity of the market as a whole is ensured by each of its participants. This is not because they *directly* see the need for integrity as such, but because it is in their self-interest not to systemically exploit the opportunity to cheat. In the end, a consciously pursued self-regulation agenda safeguards the most precious currency: one's reputation. The next section applies this rationale to the example of the emergence of central banking in the UK. Since that example also displays how regulation by a government can emerge out of the self-regulation approach, it is sensible to present it in the next section on government regulation.

An example for self-regulation is a code of conduct every firm can define for their own governance. Firms of the same industry can also define an industry-wide code of conduct. Those codes can also be initiated by consumer protections groups. Note that such conduct does not necessitate an active role of the legislator. Nevertheless, at some point the government can play an active role so that the agreed shared codes or industry standards become obligatory. This is called co-regulation (OECD, n.d.). Also, section 3.2.2 below contains the discussion of central authority and government involvement.

Take a firm-specific code of conduct for example: These are mainly values and beliefs aimed at own staff across the hierarchy but published publicly to address external stakeholders (see for example Deutsche Bank, 2014). This very much is the manifestation of the reputation argument made above. Failure to comply can result in the termination of employment. Such a code consists of prohibitions of certain conduct and also encouragement of certain positive conduct. Among others the members of staff are encouraged to question the legality of observed business practices, bring forward ideas to add to the firm, and addressing issues that could lead to reputational damages to the firm in the future.

Also an industry-wide shared and accepted code of conduct can be in place. For example, credit rating agencies (CRAs) experienced significant criticism for their business model. First, they rate the creditworthiness of bond-issuing firms with statistical methods that are not revealed to the public. So, critics point out that it is difficult to comprehend why such a “black box” should be entrusted with the assessment of creditworthiness. Second, CRAs are paid by the bond-issuing firms so that a conflict of interest is apparent (de Larosière Report, 2009).

In order to address these and related issues the first attempt to introduce an industry-wide code of conduct was initiated by the International Organization of Securities Commissions (IOSCO) in 2003. Since then this “Code of Conduct Fundamentals for Credit Rating Agencies” (IOSCO, 2015) received several revisions.

This code publishes principles with the aim to protect the integrity of the rating process, treat investors who are interested in ratings and bond issuers who are being rated fairly, and safeguard confidential information about the rated issuer. These principles are: First, the quality and integrity of the rating process. The need to decrease the information asymmetry between the credit rating industry and the financial system stood in the focus. Second, the independence of the rating and possible conflicts of interest must be free from political or economic pressure. Third, overall transparency must be increased. Fourth, non-public information about the rated issuer must be kept confidential.

At no time was this code of conduct legally binding or indicated to become. Nevertheless, the intention behind such a code can be to introduce a “comply or explain” culture in the markets. A firm would attract negative attention by competitors and customers for not supporting such a code.

The global financial crisis of 2008 has shown that self-regulation has failed to make systemic risk, which is a negative externality, an actual concern for individual investors and other market participants. Before the crisis systemic risk was too abstract and too vague to be a concern because it could not be exactly quantified. Hence it was not cared about on the micro-level. Shortly after the crisis peaked, the United Nations Expert Report (2009) on the reformation of international financial system encourages fostering intellectual diversity. The crisis was not only financially disastrous but "exposed broader flaws in the understanding of the functioning of markets. There was a widespread belief that unfettered markets are, on their own, quickly self-correcting and efficient" (United Nations Experts Report, 2009, p. 16). They do not indicate the intellectual direction, but ask for alternative economic theories and ideas to counter the monopoly of what Avgouleas calls "neo-liberal economic doctrine and deregulation" (Avgouleas, 2012, p. 110).

3.2.2 Regulation by public authorities

This sub-section focuses on financial regulation by a public authority. Goodhart and Schoenmaker (1995) do not oppose the idea of self-regulation of banks. Careful reading of their contribution brings to the point that banking itself has been growing to sophisticated levels – arguably to the point of being too complex – and new problems arise. The authors give a historical account of the emergence of central banking, especially its role in crisis prevention. Goodhart (1988) gives a comprehensive overview about the evolution of central banks. Starting with Walter Bagehot's "Lombard Street" (1873) the purpose of a central bank was to assist only "those banks which could expect to be solvent, or to regain solvency, under normal non-panic conditions, the point was clearly made that a central bank should seek to act for the public good […]" (Goodhart and Schoenmaker, 1995, p. 541). Hence, maintaining the public good was achieved by the central bank's actions, i.e. a macro-monetary policy, but indeed this task was carried out with micro-level crisis management by the central bank.

However, central banks from the early 20th century differ from today's central banks. Back then, the task of "central banking" was not government sponsored with the primacy of maintaining a public good. For example until its nationalisation in 1946, the Bank of England's shareholders consisted of banks and other private sector investors. Similarly, this insurance-like system was not too different from the joint clearing house approach in the USA, see Timberlake (1984).

From today's perspective the most intriguing aspect was that despite the absence of a formal system of regulation and supervision, moral hazard had not been too big a problem since joint rescue efforts were not exploited. Goodhart and Schoenmaker (1995) see two arguments for this: First, the public perception was that bank failures just occur and investors had been less prone to panic. Hence, the central bank had not been forced to take action and therefore the individual bank could not have been certain to receive any rescue funds. Second, peer pressure was high. A rescue would have been a joint task under the lead of the central bank and the bank subject to rescue had to be of good reputation among the other banks. There was a need to be part of such a "club" (Goodhart and Schoenmaker, 1995, p. 542) with a joint central bank. Mutual monitoring of the club members revealed "aberrant, and excessively risky, behaviour" (Goodhart and Schoenmaker, 1995, p. 542). It was the pure self-interest of each club member to spot and denounce such behaviour because if not they would later be required to contribute to a rescue and testify to the central bank (Calomiris, 1998).

Yet, this model ceased to exist. First of all, competition among banks increased from the 1960s onward in the course of deregulation. Later in the 1980s this process was further fuelled by a series of global financial integration efforts known as the "Washington Consensus" (Stiglitz, 1998). States agreed to fiscal discipline such as trade liberalization, foreign direct investments, and further deregulation to lower market entry barriers (Williamson, 1993). The club members were then not willing to survey their peers since the restrictive practices were abolished all together.

Businesses emerged with an ever more diversified product portfolio on offer to their customers, as well as exploring additional profit streams such as investment banking, trading activities, and life insurance; "sometimes on a single balance sheet or sometimes in separate non-banking entities" (George, 1997, p. 115). The financial industry has become more heterogeneous and less transparent because of this "blurring" (Thompson, 1996, p. 35) of traditional distinct businesses.

As a consequence gaps in the task of regulating can be filled with public authorities that are supported by the government. However, the intervention of a government through this co-regulation approach alters the allocation of resources. Government regulation carries the inherent risk of permanently eroding the system of how markets operate. For example, interfering in the pricing of certain goods distorts the market's ability of price discovery. In the context of banking regulation "free banker" (De Bandt and Hartmann, 2002, p. 261) scholars put the disciplining effects of market forces – like demandable bank deposits (Calomiris and Kahn, 1991; Diamond and Dybvig, 1983), as discussed in detail in section 6.4.2 – over the interference by a government, or other benevolent public authority, in order to preserve the market forces' ability of optimal resource allocation.

Nevertheless, the two approaches of self-regulation and co-regulation – with a public authority in charge – do not constitute mutually excluding approaches. On the national level the regulatory traditions play an important role. In the UK self-regulation gains more attention than in most continental European countries. There the classic command-and-control approach to regulation is more popular, which does not wait for industry initiatives that soon are supported by the public authorities through co-regulation. It is prescriptive and simply prohibits certain activities (Senden *et al*., 2015).

An example for co-regulation: Before it was replaced with a new regulatory environment in 2012, the Financial Services Authority (FSA) in the UK was the industry-sponsored single regulatory agency (FSA, 2014). However, instead of guarding over a self-regulatory code that had been formulated, the FSA’s mission and legal powers were set out in the Financial Services and Markets Act (2000) – which also applies to the current regulatory agencies in the UK, which are subject of section 3.4.2. However, the regulatory model of the FSA as an industry-sponsored regulatory agency backed up by the legislator eventually failed. Unfortunately the FSA’s approach was a “light touch” (Alford, 2010, p. 1) regulation to attract financial services but failed to recognise the potential of a meltdown of the financial system (Turner, 2009).

Then again, neither did regulatory agencies in the USA and continental Europe, regardless of their background. The Parliamentary Commission on Banking Standards (2013) in the UK concludes that regulatory failure and misjudgement of risk have led to the crisis. Those failures were due to the slow regulatory response process in general and a rules-based regulatory framework that was too much engaged with its own processes. The notion of a “light touch” regulation in pre-crisis times means that supervision of banks comprised of “mechanical data collection and box ticking” (Parliamentary Commission on Banking Standards, 2013, p. 12). Regulators must exercise sound judgement, rather than ticking the boxes, but must constantly reflect on the risks of their own judgement.

To recap the findings of chapter 1, systemic risk and therefore the concerns about the stability of the financial system has become an ongoing challenge for the financial markets and the regulatory agencies alike. Hence macro-prudence must address the negative externalities that are out of the reach – or in fact interest – of the financial institutions because they are difficult to identify. The self-regulation approach can address business conduct and how the regulated subjects engage with their customers and other market participants. But the complexity of maintaining financial stability requires a clear definition of who has the competence and accountability to engage this challenge. A centralised regulatory agency might be an obvious solution. However, the success depends not only on who engages this challenge, e.g. an industry-sponsored agency or one regulatory agency backed by the government, but also how the agency regulates. This is the topic of the next two sections before the analysis of how the regulatory environment is reshaped in the UK, USA, and EU.

3.2.3 Rules-based approach to regulation

A strict rules-based regulation prescribes the regulated subjects what they can do and what they cannot do. The advantage is that the regulated subjects know exactly what rules to abide by all the time. Recall the above example of pollution with carbon dioxide. A rule can be that each firm is not allowed to emit more than a certain amount of tonnes. There is no room for interpretation and hence misunderstanding. Also the regulatory agency in charge can underscore its accountability if it is clear that it enforces the rules.

A disadvantage is that these rules lack a degree of flexibility of the rulebook in order to match pressing problems at hand. Moreover, the rulebook can be quite extensive and the resulting compliance costs hit smaller firms the hardest for they are less likely to have vast compliance expertise (Financial Services Authority, 2007). Also the regulated subjects perceive the rules to be a box ticking exercise (Persaud, 2015). So, the rulebook in place is followed in letter rather than spirit.

3.2.4 Principles-based approach to regulation

The principles-based approach to regulation has the advantage that the regulated subjects are coerced to further look into what objectives the policy makers intend to promote. So, rather than just following policies by letter like the rules-based approach, they follow them in spirit, too. Here, the policy maker emphasises the desired outcome of regulation that can be achieved with principles (FSA, 2007). This helps regulators and regulated subjects to comprehend why the regulations are in place in the first place. The reasons for abstaining from certain behaviours enable a degree of flexibility that a purely prescriptive, rules-based approach cannot.

For example, as a matter of principle firms can be encouraged to employ production technologies that are less hostile to the environment. A rules-based regulatory framework must identify each toxin separately and introduce caps on their emissions. A simple principle can capture all of these toxins that are known to be “hostile to the environment” without strenuously defining each and listing all of them.

Obviously the disadvantage of principles-based regulation is that it comes with higher compliance costs. Especially where there is room for interpretation. Consequently, supplemental guidelines may be necessary to enable the regulated subjects to comprehend what is expected from them and minimising the room for misunderstanding.

Applied to financial regulation, a lack of clarity is also a cause for confusion within a principles-based regulation. The BCBS (2012) issued the Core Principles for Effective Banking Supervision. There, the 16 Principles for “prudential regulations and requirements” give guidance to the regulatory agencies’ tasks to supervise banks. Ten of them use the term “adequate” to define what the prudent agency should look for in a bank. A lack of precision is inherent to the definition of what is “adequate”. So, these Principles merely point to the direction of what prudential supervision should resemble, yet the national supervisory agency – together with its legislator – should formulate in more concrete terms what they expect of the regulated banks. For example, a stark mismatch between the performance of banks and excessive remuneration has been observed during the crisis. A cap on remuneration or a deferral of the pay-out of bonuses is currently under way in the EU. However, the there are exceptions to this deferrals. The guidelines on sound remuneration policies issued by the European Banking Authority (EBA) apply within these exceptions. So, where concrete rules for remuneration do not apply, e.g. small institutions or where the variable remuneration is a small portion, the “principle of proportionality” (EBA, 2015a) applies. Nevertheless, even the EBA admits that these instances raise “interpretation issues for institutions, competent authorities, the EBA and the European Commission” (EBA, 2015a, p. 3).

Obviously a principles-based approach makes compliance for banks an ongoing task rather than a once-a-year routine. Also the regulatory agencies have to constantly revise and adapt new principles to make sure that the regulatory framework is not outdated like a stiff rules-based framework is likely to eventually become over time.

Note that the two approaches of rules-based and principles-based regulation are not mutually exclusive, but complementary. The overall regulatory framework can consist of rules and principles. So, for unambiguous fundamental factors in financial regulation, like the loss-absorbency of each bank, minimum capital requirements can be introduced; banks simply have to abide by these quantitative rules. Principles are more appropriate where sources of risks vary case-by-case and can best be addressed by banks themselves. For example a principle of a fair treatment of customers would require banks to know their individual customer’s needs and tailor solutions adequately. However, the strengths of principles can only be revealed if compliance can actually be measured (Kling, 2012). For example, the Prudential Regulation Authority, the UK's financial regulatory agency, requires, among others, that "[a] firm must at all times maintain adequate financial resources" (PRA, 2016, p. 9) and that "[a] firm must act in a prudent matter" (PRA, 2016, p. 9). Compliance with the former can be measured by comparing the calculated capital cushion to the current market environment. A gap enables the regulatory agency to take action. In contrast, compliance with the latter is difficult to measure. Not complying with such a prudent manner is only identified *ex post*. So, further definitions and examples for what is and what is not "prudent manner" must be provided.

3.3 Different ways to create a regulatory architecture

This section focuses on how a regulatory agency can be constructed. In addition, the section als demonstrates the difficulties in creating a global regulator. In the UK the Turner Review (2009) concluded that the two to three decades prior to the 2008 crisis were dominated by three intellectual arguments: First, efficient and liquid financial markets make available a full range of contracts to fulfil lenders' and borrowers' preferences for risk, return, and liquidity. Second, "markets are sufficiently rational as to justify a strong presumption in favour of market deregulation" (p. 40). Third, even if irrational behaviour occurs, policymakers cannot be able to make a sound judgement about how heavy this irrationality weights and justify interventions.

Given the experience from the 2008 crisis, in the EU the Larosière Report (2009) concludes that the crisis results from:

> "the complex interaction of market failures, global financial and monetary imbalances, inappropriate regulation, weak supervision and poor macro-prudential oversight. It would be simplistic to believe therefore that these problems can be 'resolved' just by more regulation. Nevertheless, it remains the case that good regulation is a necessary condition for the preservation of financial stability" (p.13).

The particular challenge of creating a macro-prudential framework is to define "good" regulation. A simple suggestion is that good regulation first addresses the relevant problems. Second, on the part of the regulatory agency the regulations are enforced. Third, a good regulatory regime allows the regulatory agency to keep pace with the latest developments of the regulated industry, here addressing systemic risk in particular. So, in drafting new regulations and revising existing regulations, policy makers must enable an adaptability of the rulebook. As the previous section shows, a more principles-based approach is best suited for this.

Financial stability is a global public good (Shirakawa, 2012). Hence domestic policy makers and regulators must co-operate in addressing systemic risk. The path towards a shared regulatory catalogue is by no means a simple task. Even if regulatory reforms, for example minimum capital requirements, have been agreed on an international level, the implementation of the reforms itself becomes the subject of dispute. Blackmore and Jeapes (2009) identify that the "key defining feature of this financial crisis distinguishing it from other crises is its global nature which has led to oversee the global financial system and to prevent another global crisis on a similar scale happening again" (p. 113).

Policy makers now refurbish the regulatory framework – i.e. regulations imposed on banks and architecture of the regulatory agencies – and allocate new responsibilities to regulatory agencies and the legal powers to exercise them. In the light of the above citation, a unified global regulatory approach seems plausible. However, as the next sections show, different legislations pursue different approaches to put macro-prudence into practice. The change of the regulatory frameworks in the UK, USA, and EU serve as examples.

These are the four stages to form a single global regulatory agency (see Bollen, 2008): First, the member states that generally agree on the necessity of international standards discuss a road map. There is no immediate urge for commitment to adopt the standards. However, these discussions might be just too vague and identify the lowest common denominator, or as the most critical voices would call it, a "race to the bottom" (Bollen, 2008, p. 7). However, these international institutions have no formal mandate to give legally binding orders. This "soft" law (Zaring, 2012) is frequently dismissed as policy makers paying lip service to the good will and nothing will happen afterwards (Gersen and Posner, 2008; Macey, 2003). Much depends on the momentum the willingness of member states to push forward the standard setting. Yet, this criticism can be circumvented by introducing a "comply or explain" policy where member states can "black-list" those member states that do not communicate a commitment. For example, the U.S. Federal Reserve will not allow foreign banks to open a branch unless the regulatory framework in its home country recognises standards similar to the U.S. standards (Hendell, 1994). There, the pressure of a "comply or explain" culture introduces peer pressure among the competitors analogous to the county-level negotiations of standards we currently observe.

Second, coordinating a serious commitment occurs through regulatory colleges provided by multinational forums such as the BIS with regards to global banking regulation. There scholars with the necessary expertise, policy makers and their national regulators, and business representatives can pave the path towards drafting regulatory standards (Felsenfeld and Bilali, 2004). The following section 3.4.1 discusses the Basel accord.

Third, the implementation into national regulation is assisted by a body that supervises the national regulators. For example, the Basel Accord Implementation Group consists of senior regulators from across the member states (Federal Reserve, 2003) and acts as a service provider to clarify implementation issues. Now the international efforts are already beyond setting the standards for the regulated industry. The implementation process is now in the focus. Hence at this stage the multinational forum, or college, has spawned a "global coordinator" (Geiger, 1998, p. 47).

Fourth, the ultimate stage is a "supreme global regulatory body" (Felsenfeld and Bilali, 2004, p. 107) that directly regulates banks. This would require the global regulator to be backed up with a clear mandate and the legal provision by the member states. For example, reforms in the EU come close to this with plans to make the ECB the single regulatory agency.

Independent from the stage in which the international efforts are, the decision makers have to decide on the architecture of the resulting agency. This applies to both a global regulatory agency and a purely domestically operating regulatory agency. There are four approaches. Policy makers can base their choice starting with the regulatory agency they want to have (Fresh and Baily, 2009). This can be a single, "unified supervisory agency" (Llewellyn, 2006, p. 23), in the integrated approach, or two regulators in the twin peaks approach. Alternatively, they can create the regulatory agencies according to the shape of the regulated industry. If so, the functional approach focuses on the services industry provides regardless of its legal status, potentially restricting arbitrage. The institutional approach does recognise the legal status. The latter two approaches pose a considerable challenge to the regulatory agency (or agencies). The regulated industry can broaden their services faster than the regulator can catch up with. The institutional approach suffers from its inflexibility.

Recall the definition of "macro-prudence" from section 2.5. At the centre of macro-prudence lays the deeper insight that the stability of the financial system is not the sum of the stability of each element of the system, especially banks. Developments on the micro-level can accumulate to issues on the macro-level. Two further obstacles emerge: First, who should address such macro-prudential issues? Is an industry-level self-regulatory body able to this?

Or is a regulatory authority with the legal backup better suited? Second, on what level should macro-prudence be addressed? A globalised financial system would require that macro-prudential issues are addressed on an international level. This in turn would require that the different national jurisdictions agree to harmonise regulatory standards.

To answer the first question, the individual financial institution must care about the problem in the first place. Since negative externalities are the core of the problem, the individual institution does not care about internalising. So, a self-regulatory framework is not likely to persist in the long run because the industry has no incentive to care enough about the problem, hence does not internalise it.

In regards to the second question, addressing a global problem on a global level seems to be the appropriate solution. However, the challenge can turn out to be impracticable. This requires reconciling the national interests of various countries that need to hand over significant parts of their sovereignty of regulating financial institutions. Nevertheless, international co-ordination and standard setting through forums like the BIS and BCBS Basel accord can lead to a holistic, harmonised macro-prudential approach that is equally enforced on a national level. Currently, elements of the latest version of Basel III are continuously adopted among the 27 member jurisdictions (BCBS, 2016).

Consequently it is argued that for the purpose of creating a macro-prudential regulatory environment on a national level, the integrated approach and the twin peaks approach qualify. Regulatory agencies that follow an integrated approach are the universal regulator for all types of financial institutions, ranging from deposit-taking banks to proprietary trading investment banks, insurers, and other financial institutions (Fresh and Baily, 2009). Llewellyn (2006) distinguishes between integrated and unified regulators. An agency is integrated if it exercises prudential supervision; an agency is unified if it exercises prudential and conduct supervision at the same time. This differential treatment is not followed in this thesis.

The advantages of a single regulator are that regulatory arbitrage is abated and information gathering is centralised (Briault, 1998). However, the more universal a regulator is, the less specific the regulatory expertise can be (Llewellyn, 2006). Because of the sheer size of the regulatory agency, it might be the case that the senior executives prioritise a few aspects of the agency’s tasks and allocates the agency’s resources accordingly. The potential threat is that other parts of the regulated subjects are left unrecognised or under-recognised. For example within a unified agency, customer protection could be prioritised in times of financial tranquillity to the detriment of systemic risk concerns.

Alternatively, the task of regulation can be given to a prudential agency and a conduct agency. Both coexist in one jurisdiction and address the same industry but from different angles. This "twin peaks" (Taylor, 1995 and 1996; Goodhart, 1996) model of regulatory architecture is "based primarily upon the objectives of regulation, albeit fine-tuned to take account of market developments and of the need for accountability and efficiency" (Briault, 1999, p. 24). These objectives are safety and soundness (prudence) and consumer protection (conduct). Both regulatory agencies have advantages in catching up with trends in their respective fields and are more likely to develop specialised knowledge (Llewelyn, 2006). If their findings are merged accordingly, a comprehensive assessment of the regulated industry can be derived. A disadvantage one might think of is that the regulated industry has to comply with two sets of regulatory requirements, hence the compliance costs increase. However, the twin peaks approach can be more effective than a single agency. A conduct regulator usually requires legal expertise in consumer protection whereas a prudential regulator requires expertise in the field of economics (see for example Select Committee on Economic Affairs, Banking Supervision and Regulation, HL 101-I). The work of macro-prudential regulators can go hand in hand with the classic monetary policies performed by the central bank, see the UK architecture in section 3.4.2.2.

3.4 How macro-prudential regulation is put in practice on a national and international level

The previous sections highlight the difficulties in combining the difficult nature of macro-prudence and choosing a regulatory architecture that is best suited to put macro-prudence into practice. This section analyses in more detail the concrete plans and what has already been done to reshape the regulatory frameworks in the UK, USA, and EU. The comparison of advantages and disadvantages of the respective frameworks help answer how macro-prudent the respective regulatory architecture and regulations in place are. For example, the architecture in the UK experienced a complete overhaul with new regulatory agencies, whereas in the USA existing regulatory agencies are re-shaped and new ones are added. In the EU the ECB is gradually building up more competences towards a unified regulatory structure. As for regulations, the most prominent example is the ring-fencing of deposits in the UK, scheduled to be implemented in 2019, that banks simply have to abide by and the prohibition of proprietary trading in the USA.

The pre-crisis paradigm was to address the financial safety and soundness of the individual regulated financial institutions (Turner Review, 2009). The lessons learned from 2008 are that the aggregate of the individual institutions does not equal the stability of the system as a whole. How interactions of the regulated subjects occurred in the broader financial system, i.e. in the borrowing and leveraging and maturity transformation was neglected. In summary, a holistic approach of macro-prudential regulation includes scrutinising the asset side of individual banks as well as the liability side of the bank's balance sheet. For this, recall the case of Northern Rock from the previous chapter. Figure 3.1 illustrates the shift from the old to the new regulatory approach.

Figure 3.1: Pre-crisis and post-crisis regulatory paradigms. Source: International Monetary Fund (2013).

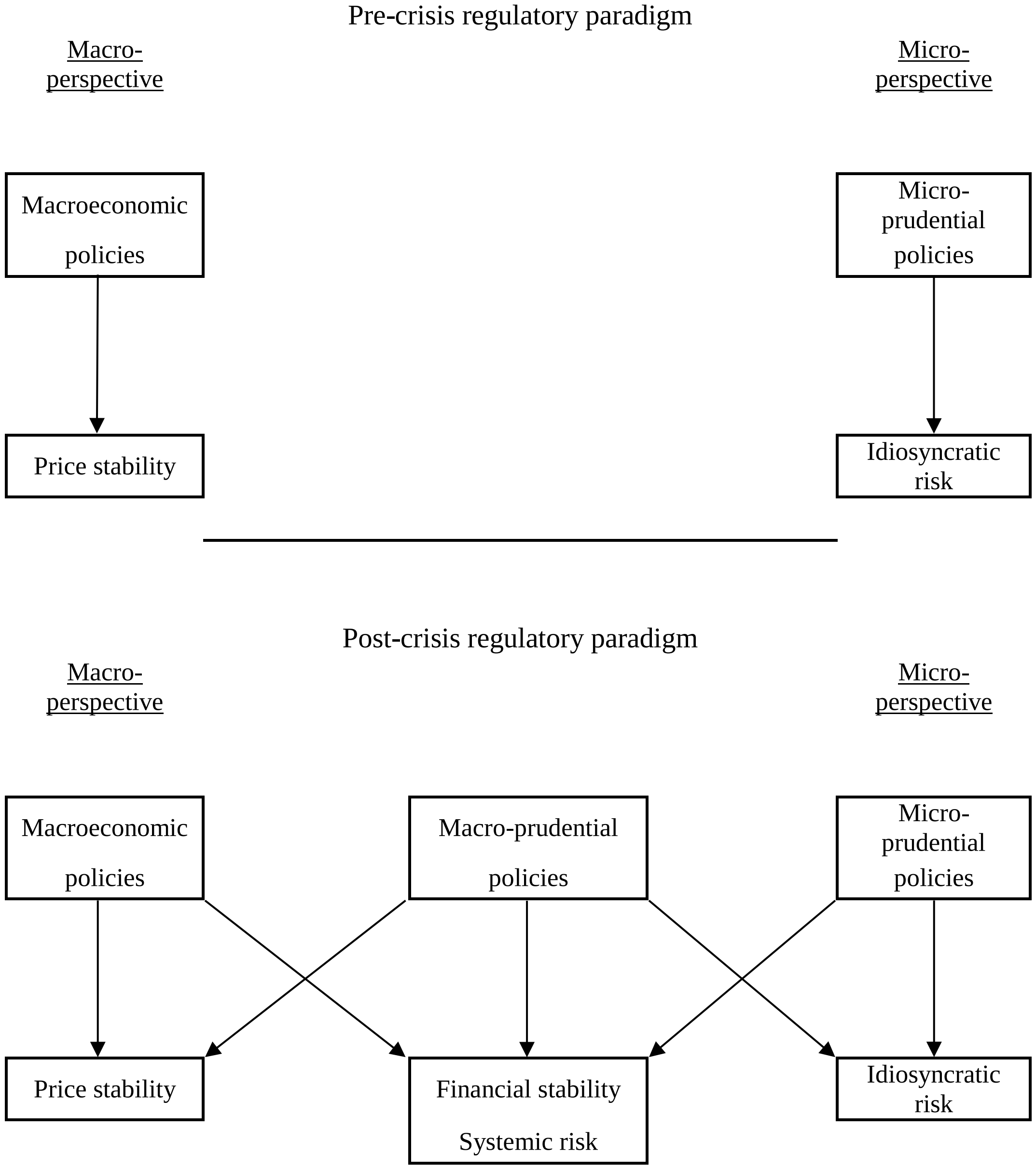


Figure 3.1 above illustrates the gap in the regulatory approach before the crisis and the place of macro-prudence after the crisis. Before the crisis macro-economic policies, like monetary policy, are subordinated to the objective of maintaining price stability. The regulation of banks had a micro-prudential scope. After the crisis, macro-prudential regulation aims at filling the gap between the two. Financial stability is the second main objective coequal to price stability. Macro-prudence has to reconcile issues of price stability, the idiosyncratic risk of individual banks, and the externalities stemming form the interconnectedness on the micro-level, i.e. systemic risk.

After the gap in the regulatory paradigm has been identified and is filled with a macro-prudential approach, in the next step policy makers must mould the new regulatory agencies into a specific form. The regulatory frameworks in the UK, USA, and EU are examples of how macro-prudence is interpreted differently. The framework consists of what new regulations are imposed on banks and how their respective regulatory architecture is overhauled. These points are subjects of sections 3.4.2, 3.4.3, and 3.4.4, respectively.

A further reason of concern is basing the rationale for having several regulators dependent on the regulatory objective. For example, in the functional approach, there is one special regulator tasked with "systemic" concerns across all financial institutions. This necessitates that the boundaries of the regulator's operating range is blurred, so that agency has access to banks and non-bank financial institutions alike to fulfil its objective. Because "a wide range of firms can now create potentially systemic problems" (Taylor, 1995, p. 4; George, 1997), the operating range of the regulatory agency must be increased. In addition, again, a principles-based approach to regulation would make it easier for regulatory agencies to have this impact.

Dudley (2014) submits three distinctive characteristics of prudential supervisionthat help tell the success of a new framework: fairness, conscientiousness, and effectiveness. All three of them translate into the corporate governance of the regulatory agencies that exercise the actual prudential supervision.

Fairness is the consistent applications of rules across the regulated subjects. Regulatory decisions must be exercised without any influence from the business side or political wishes.

Conscientiousness aims on how the regulatory agency perceives itself; it must be honest about its own work and self-critical analysis must be followed by the willingness towards self-improvement. This is a crucial point and must not be underestimated. Hence, an internal revision department or similar system is necessary to conduct annual reviews whether the agency captures developments in the regulated sector.

Effectiveness of prudential supervision means that the agencies and supervisors are indeed tough on banks, meaning that they have the "teeth" and are not afraid of showing them.

The Beim report (Beim, 2014) gives valuable insight into the cultural failure within the Federal Reserve to comply with those standards. For example, consensus-seeking among supervisory staff has damped the efforts to nurture a culture of debate that would eventually lead to better regulatory outcomes.

3.4.1 International coordination of financial regulation with the Basel accord

Before the plans for introducing a macro-prudential framework in the USA, UK, and EU are analysed, this sections gives a brief introduction to the Basel capital accord that is widely considered as the global standard for recommending a financial regulation rulebook.

The BIS is one of the various forums where central banking issues and financial regulation are discussed and make it to a proposed standard. The crisis of 2008 resulted in a reviwed version of the Basel minimum capital accord, i.e. Basel III. The participants range from the area of academia, policy makers, and practitioners from both sides of the daily regulatory work, i.e. central bankers and bankers. The need for coordination efforts on a global level is reinforced with the realisation that systemic risk is a new risk category in its own right.

One of the achievements of these high-level discussions was the Basel Accord on capital requirements that ought to create a level playing field for banks' loss-absorbency. The second Basel Accord on capital requirements, Basel II, was drafted in the late 1990s to address the shortcomings of its predecessor Basel I. Currently Basel III is phased in until 2018 and addresses the shortcomings of Basel II. Basel II defines a three pillar regulatory framework that aims to be introduced into national financial regulation.

The first pillar stipulates how banks calculate the minimum capital requirements. Pillar two addresses the process of the supervisory review. This enables the regulatory agencies to control the capital calculations of the banks. The third pillar reinforces market discipline. When market forces exercise such discipline, banks produce transparency about their business (Wall, 1989; Flannery, 1998).

There is plenty of criticism on this framework not only in the aftermath of the 2008 crisis but also during the draft stages. The rulebook is incomplete and by no means is a comprehensive framework. A correlation between credit risks is ignored. This means that the credit risk of individual borrowers is assumed to be dealt with in isolation, which is not the case since borrowers are exposed to the same macroeconomic factors. For example they share the geography and are exposed to the economic prosperity of the region. Recall the sub-prime crisis where the credit risk of sub-prime mortgage takers in the USA was highly sensitive to changes in the level of rates at which banks lend to each other, such as the LIBOR. Further examples are given in Admati and Hellwig (2013, p. 312f, footnote 64).

The technical flaws of Basel II are raised in Daníelsson *et al*. (2001). Especially grave is the criticism of the treatment of risk as exogenous to banks. In fact the financial system is threatened by endogenous risks, for example the systemic risk stemming from the individual financial institution. The capital requirements actually introduce procyclicality and exacerbate the threat of systemic instabilities. Neither pillar sufficiently addressed this. So, banks tend to lend more than is sustainable from a systemic point of view. Similarly, during market downturns banks further tighten their lending. But the lending is needed for the economy to recover sooner than later. How this issue is addressed with countercyclical capital requirements is the subject of the next chapter where macro-prudential tools are analysed.

Furthermore, the incentives Basel II regulations aimed to set for the regulated subjects are ill-aligned (see Calomiris, 1998). Jamie Dimon, CEO of JP Morgan Chase, made no secret of the bank’s attempts to exploit the existing rules on risk-weighted assets (RWA) to the best. In his words the bank will “manage the hell out of RWA” (Braithwaite, 2011) to minimise the regulatory capital buffer. Banks put in more effort to arbitrage the existing rules rather than managing the business risk they face, which of course should be the intention behind such regulations in the first place. So, more needs to be done to emphasise that banks should abide the rules by spirit rather than just by letter.

In the following sections the new and revised regulatory agencies in the UK, USA, and EU are compared. The changes of the regulatory environments are analysed in regards of their fairness, conscientiousness, and effectiveness to fulfil the macro-prudential paradigm.

3.4.2 Regulatory change in the UK

This section analyses the regulatory framework in the UK. The framework is further divided into the new regulations banks have to abide by and the architecture of the regulatory agencies in the UK. Additional regulatory instruments at the UK regulator's disposal aim on curbing lending with imposing different ratios in the actual lending business. For example a mortgage can only be granted if the mortgage is sustainable, measured by dividing the value of the mortgage to the borrower's income. The regulatory agency decides on the exact level of this ratio. However, the following sub-sections focus on the organisational requirements imposed on banks to harmonise with the regulatory architecture in place; the regulatory instruments such as ratios are analysed in more detail in the next chapter.

3.4.2.1 Regulatory action in the UK: Ring-fencing deposits

The Turner Review (2009) identified the need to formally isolate specific activities of banks in order to make them more manageable for the regulatory agencies. This "ring-fencing" (Turner Review, 2009, p. 99) of activities has been reinforced in the final report of Independent Commission on Banking (ICB) in 2011 and is scheduled to be introduced in 2019. It is consequently developed further with the aim of ensuring that distressed entities, especially in regards to retail banking that provides credit intermediation vital to the economy, "can be resolved in an orderly manner" (Prudential Regulation Authority, 2014, p. 5) without taxpayer liability and major disruptions to the core services of the banking sector. These core services are provided in the form of the deposit-taking entities, payment system, and credit supply to households and businesses in the UK (ICB, 2011). Note that this is not a complete decoupling of core services from other financial services. Rather, existing bank holding groups have to adapt their organisational structure in a way that, in principal, allows the ring-fenced activities "to take decisions independently of other members of its group" (see 142H of the Act, as amended by the Financial Services (Banking Reform) Act 2013.). This formal independence of decision making must be accompanied by a resource independency. It must be ensured at all times that the failure of one or more members of the bank holding company does not affect the resources available the ring-fenced entities. One driving factor was that secured deposits served as funds to finance investment decisions bank could not sustain. Consequently, several additional prohibitions and specifications must apply to the ring-fenced entities. These include prohibitions on intra-group guarantees to make sure that other parts of the bank holding company do not have access to secured funds to equalise losses in their business. Furthermore, intra-group transactions such as loans and asset sales must be priced under market conditions “as if they have been carried out between unrelated parties” (Baber, 2012, p. 3) to avoid disguised cross-financing (HM Treasury, 2012a). In return, the regulatory agencies have easier access to the entities because of the ring-fence and so are easier to protect. These regulatory objectives in respect to the ring-fence are defined in section 2B of the Financial Services (Banking Reform) Act 2013.

Furthermore, this ring-fenced entity is prohibited from investing in “excluded activities” that would expose the entity to shocks in the financial markets (HM Treasury, 2012). The Financial Services and Markets Act 2000 (Excluded Activities and Prohibitions) Order 2014 defines these excluded activities. For example, trading commodities, such as trading in the future contract market for sugar, is prohibited, see article 5. However, general exceptions are granted. The status of the activity depends of the purpose of the particular investment. Trading commodities for the own account, called proprietary trading, is prohibited. Yet, the ring-fenced entity can trade the commodity if the trade is part of the risk management, such as addressing liquidity risk (article 6(3)(a)) or any other purpose. However, there might be potential for arbitrage when the “prohibited activities” can be disguised as being part of addressing the own risk management as an “ancillary activit[y]” (HM Treasury, 2012b, p. 10). This requires the regulatory agencies to continuously review the business conduct of the bank. The ring-fence structure decouples the vital services to the economy from risks stemming from an exposure to financial markets. Consequently, this separation can reverse some of the synergies between the ring-fenced activities and the other groups of the bank holding company (Baber, 2012).

The regulatory agencies must not operate on a zero-failure regime and protect these entities at any costs. As long as a failure is orderly, market discipline must not be replaced with a protection by the regulatory agencies.

This way of modernisation the regulatory paradigm is insofar remarkable for it does not merely make the regulatory structure fit the current state of the regulated industry but also imposes structural requirements on the industry itself to make it fit the regulatory agencies. The banking industry’s ability to arbitrage the system is limited. This can turn out to be a significant advantage for the effectiveness of the regulatory regime, so it delivers macro-prudence.

3.4.2.2 Architecture of the regulatory agencies in the UK

A formal separation of central banking and the regulation and supervision of the banking sector is merely a preference of a country (Goodhart and Schoenmaker, 1995). There are no compelling arguments whether a model of strictly separated monetary policy and supervision or a single national body is the better model. Even if the two are formally separated, in practice they would have to – and indeed do – work closely together anyway.

Turner (2009) notes that in retrospect the division of micro- and macro-prudence was not beneficial, compare upper panel of Figure 3.1. The Bank of England

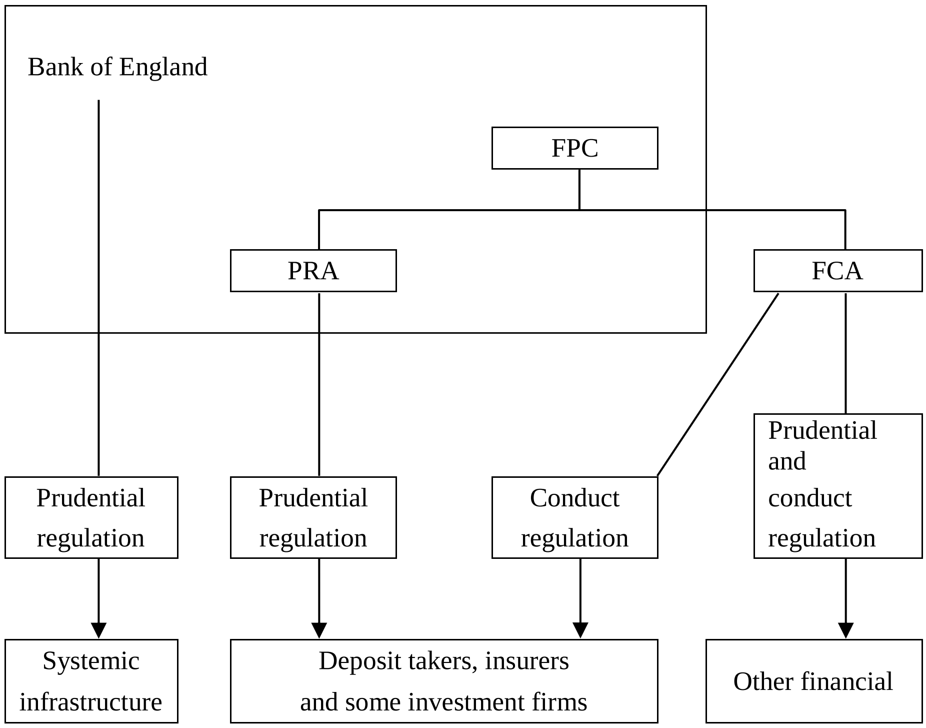
> "was focused on its monetary policy mandate. The FSA focused on micro-prudential supervision on an institution by institution basis, and on an interpretation of that which was fairly legalistic and focused on systems and processes. Somewhere between the big picture got lost; the overall trends in credit extension across the economy and in assets prices were not put together with certain business developments to sound a warning" (Turner, 2009a).

There is a preference in the UK towards preserving sovereignty over the domestic financial services industries. The UK has a market share of 39 per cent of EU stock exchanges measured in stock turnover (De Haan *et al*., 2009). The UK is also subject to efforts of regulatory convergence in the EU, which are subject of section 3.4.4. The EU and UK have different opinions about certain regulations. Hence frictions could diminish the overall effectiveness of macro-prudence on a global level.

The UK follows a twin peaks structure, see Figure 3.2 below for an illustration. The Prudential Regulation Authority (PRA) is primarily concerned with systemic risk and accordingly financial stability. The Financial Conduct Authority (FCA) addresses the protection of the consumer. The Financial Policy Committee (FPC) connects the prudential supervison of banks exercised by the PRA and the monetary policy decisions of the Bank of England. The FPC and PRA are located within the Bank of England and exercise macro-prudence. The FCA is located outside, but in contact with the FPC.

The list of available tools at the FPC's disposal in non-exhaustive. It is deliberately given the freedom to revise and develop tools as they see fit for the regulatory objective of maintaining financial stability. These tools include countercyclical capital buffers, leverage ratio, and limiting lending to housing. The tools are described in more detail in the next chapter.

Figure 3.2: The new regulatory structure in the UK. Source: Bank of England (2013).



The FCA has the ability to intervene in financial product design. The conduct regulators support the banks in the design process, yet the responsibility towards designing appropriate products lies with the banks. However, the Commission on Banking Standards (2013) point out that in exercising judgement, the FCA faces a tightrope walk: On the one hand too early an intervention could lead to market distortions to the detriment of consumer benefit. From the regulated subjects' point of view this constitutes regulatory uncertainty and has to be factored in in the process. On the other hand, late intervention makes consumers suffer as the mis-selling of Payment Protection Insurance (PPI) by British banks has demonstrated. Customers with PPI bought an insurance against outstanding loans such as mortgages and credit card bills due to falling ill or losing their jobs. But "it will be years before […] this mis-selling scandal is over" (Wayman, 2015). In cases where banks were involved, a customer only signed for a mortgage and the insurance was sold on top of it. It was not fully clear to the customer that PPI was a separate product that the customer could have rejected. This raises more general doubt about the ill-aligned cross-selling procedures in banks and the customers' needs.

The PRA has the objective of maintaining safety and soundness of its supervised institutions, and as second, nevertheless subordinated objective, promoting competition. In October 2014 the PRA issued a series of Consultative Papers addressing these aspects (see PRA, 2014). Part of the primary objective is the deposit-protection within the ring-fenced entities as set out in the Consultation Paper CP20/14 (PRA, 2014a), with regards to insurance companies to promote a degree of protection of the insurance policy holders (see CP21/14, PRA, 2014b), and fostering effective competition. In fulfilling its regulatory objectives it employs a judgement-based, forward looking, and focused strategy. The judgement is based on concrete evidence of current risks. Forward looking means that the PRA aims at anticipating future sources of risks and to intervene on an early stage. The focus lays on those issues and firms that pose the highest risk to the regulatory objectives.

Macro-prudence is exercised with co-operation between the FPC and PRA within the Bank of England. The Financial Policy Committee (FPC) was established under the Bank of England Act 1998 with amendments in the Financial Services Act 2012 and began its work in April 2013. However, section 9C(4) of this Act reinforces that the FPC's must not intervene at any costs when the consequence would be "a significant adverse effect on the capacity of the financial sector to contribute to the growth of the UK economy in the medium or long term". Its mandate gives the FPC the power to first make recommendations to the regulated financial institutions and its subordinated regulatory agencies, the PRA and FCA, and second the power to direct these regulators to adjust specific macro-prudential tools. The FPC employs a quarterly cycle of reviewing their policies. It starts with briefings coming from the Bank of England's economists, market intelligence, analysis from the PRA and FCA, and impact studies of existing policies that are put in place. Second, FPC "issues meetings" take place to discuss major threats to financial stability in the UK and what macro-prudential instruments might put into policy to counter the threats. Third, in the "policy meeting" appropriate steps are taken to draft needed policies. Fourth, the FPC communicates their finalised statements and recommendations to the identified threats in the Financial Stability Report.

The FPC's "power to recommend" (Haldane, 2013) actions to the PRA and FCA is based on a 'comply or explain basis' (Bank of England, 2013a). The PRA and FCA are given the opportunity to explain their opinions on the *recommendation*. On the other hand, *directions* forwarded by the FPC must be implemented in due course. For example, the FPC gives the direction to change the capital buffers for banks. The FPC recognises that there can be procedural obstacles. Therefore it further issues a recommendation to its subordiantes agencies "on the timing of implementation alongside its Direction [sic!]" (Bank of England, 2013a, p. 13).

The FPC pledges to have an informal meeting of regulatory staff from various seniority and business representatives (Haldane, 2013; Kohn, 2013). This is the environment in which critical thinking is not promptly dismissed. Instead the ideas are assessed to their relevance and further reduced to their core issues to shape the course of the discussion. For example, front-line supervisors who are in contact with the regulated subjects report on their interviews they conducted. All of this hard and soft information are gathered and then, through discussions, urgent problems that affect resilience are prioritised.

3.4.2.3 Interim observation on the regulatory change in the UK

In conclusion the UK approach has resemblance to the twin peaks model of regulation. The Financial Policy (FPC) committee is a subsidiary of Bank of England. The PRA and the FCA are the coequal regulatory agencies that are direct in touch with the regulated subjects. The macro-prudential paradigm is reflected in the work of the PRA and the Bank of England. Both deal with systemic risk concerns stemming from the financial system structure, deposit-taking banks, and other systemically relevant institutions. The FPC deals with consumer protection by addressing how financial institutions treat their customers.

In terms of fairness, the FPC makes sure to hear the opinions from the regulated subjects and their own front-line staff. Frictions in discussions seem to be embraced rather than aiming for a consensus for its own sake. This goes hand in hand with conscientiousness. An informal environment makes it easier to reflect on the agency’s own work. The regulatory approach is perceived effective if the regulatory agencies enforce the rules consistently without hesitation. The ring-fencing of deposit-taking units allows the regulatory agencies to exercise their powers within their mandate without increasing the threat of regulatory arbitrage. However, drawing a clear line between excluded activities and ancillary business can turn out to be a difficult task. It is foreseeable that compliance costs increase because the bank must provide evidence that the trading activities are for the sole purpose of risk-managing and not proprietary trading.

The discrimination between conduct regulation and prudential regulation respects the different cultures necessary to perform the different tasks. Conduct regulation is often exercised by lawyers and prudential regulation asks largely for expertise in economics (Select Committee on Economic Affairs, Banking Supervision and regulation, HL 101-I, p. 33), especially with macro-level implications that go hand in hand with monetary policy exercised by the central bank.

The framework is coherent and in itself is less likely to introduce regulatory arbitrage. The change in the shape of the banking sector in the UK, where deposits are planned to be ring-fenced, allow the regulatory agencies better access to the protection-worthy services. The threat that financial losses, due to a shock somewhere in the financial system, find their way into the regulated areas is decreased.

3.4.3 Regulatory change in the USA

This section analyses the regulatory framework in the USA. The framework is further divided into the new regulations banks have to abide by and the architecture of the regulatory agencies in the USA.

3.4.3.1 Regulatory action in the USA: prohibition of proprietary trading

The 2010 Dodd-Frank Act is the legal foundation for the new regulatory and supervisory framework in the USA. Section 619 of the Dodd-Frank addresses the structural changes to the banking industry. This section prohibits proprietary trading and certain relationships with hedge funds and private equity funds. This prohibition, also known as Volcker rule, originally intended to ban deposit-financed proprietary trading. Former Federal Reserve chairman Paul Volcker, who gave this rule its name, reinforced that a complete separation of the two activities is paramount. Even an intended protection by ring-fencing is not optimal. In his consultative evidence given to the UK Parliamentary Commission on Banking Volcker points out the impossibility to have both activities in the same organisation and expect that there will be no interactions between them in one way or the other (Volcker, 2012). So, only a complete separation dismisses the slightest semblance of arbitrage.

Consequently, this Volcker Rule would prohibit proprietary trading of securities, derivatives, commodities futures and options if they do not benefit a bank’s customer. If large losses in these parts of the financial system occur, banks would simply not be affected directly. The original date of implementation was scheduled for 2010 but constant renegotiations delayed the implementation of a revised, less strict Volcker rule to 2014 with a one year phase-in period. However, this still goes well beyond the trading restrictions introduced in the UK. Consequently, in 2015 banks that are subject to U.S. regulations either cut their proprietary trading desk significantly or removed them altogether in order to avoid compliance with the regulation (Financial Times, 2015).

Under the Volcker rule in its current form banks are allowed to participate in such activities within narrow boundaries and conditional on comprehensive reporting requirements. Instead they chose to remove them from their bank-affiliated broker-dealers. This would leave a gap in the international trading of these financial instruments that would be filled by non-bank providers that are not subject to extensive regulations. This alteration could "have unpredictable and potentially important adverse consequences for financial stability" (Duffie, 2012, p. 2).

3.4.3.2 Architecture of the regulatory agencies in the USA

Section 111 of the Dodd-Frank Act is the basis for the Financial Stability Oversight Council (FSOC) that has begun its work in January 2010. The FSOC is on top of a group of regulatory agencies that build a closely meshed web of authorities to request information and exercise supervision over different kinds of financial institutions in the USA. The Office of Financial Research (OFR) and the Bureau of Consumer Financial Protection (CFPB) are also two new agencies. The OFR does not examine any institutions directly but collects information for research purpose and communicate them to the FSOC. Furthermore it provides a forum for the exchange of research and develops the tools to assess financial stability not only nationally, but also serves as a link to the global efforts to co-ordinate the mitigation of systemic risk (Systemic Risk Council, 2016). One example is the gathering, discussion, and improvement of different measures to calculate systemic risk (Bisias *et al*., 2012). The conditional Value-at-Risk (Adrian and Brunnermeier, 2009) is one of these measures. Chapter 5 of this thesis contains an empirical analysis applied to European bank data.

The Act therefore stipulates an institutional approach by identifying financial institutions according to their legal status and does not base the regulatory structure according to the functions that are exercised (Acharya *et al*., 2010).

In sum there are eight agencies the financial system has do deal with directly plus the FSOC that requests information from most of the other agencies. These agencies are: the Federal Reserve, the Office of the Comptroller of the Currency (OCC), the Federal Deposit Insurance Corporation (FDIC), the National Credit Union Administration (NCUA), the U.S. Securities and Exchange Commission (SEC), the Commodities Futures Trading Commission (CFTC), Federal Housing Finance Agency (FHFA), and the Bureau of Consumer Financial Protection (see Murphy, 2015).

The FSOC is tasked with identifying and countering systemic risk threatening systemically important financial institutions (SIFIs) and systemically important “Financial Market Utility” (FMUs) alike. The latter are “any person that manages or operates a multilateral system for the purpose of transferring, clearing, or settling payments, securities, or other financial transactions among financial institutions or between financial institutions and the person.” (Dodd-Frank Act, 12 U.S. Code § 5462 (6)(A)).

If the FSOC deems a firm’s kind of business systemically relevant, the FSOC can designate a FMU status to such a function if its smooth operation is essential to encounter systemic risk. The Board of Governors of the Federal Reserve System (2014) interpret the FMU status concretely as the providers of:

> “the essential infrastructure for transferring, clearing, and settling payments, securities, and other financial transactions among financial institutions or between financial institutions and the system. In cases where a failure or a disruption to the functioning of an FMU could create, or increase, the risk of significant liquidity or credit problems spreading among financial institutions or markets and thereby threaten the stability of the U.S. financial system, the FMU may be designated as systemically important by the Financial Stability Oversight Council.“ (FRS, 2014 online).

Finally, if necessary the FSOC can make a decision to break up companies if they are a threat to financial stability.

As of 2015 there are eight designated systemically relevant FMUs. These are corporations offering clearing house services. The FSOC designates the FMU status according to first, the outstanding monetary value processed by the financial institution in question, second its aggregated exposure to counterparties, third interactions with other clearing houses that are or are not FMUs, and fourth, the impact a disruption or complete failure of this entity would have on certain markets or even the whole financial system (FSOC, 2012). Possible disruptions in the financial system can be countered where they are likely to be detected first. The FSOC hence does not wait until the observed disruptions enter the banking system to take action.

Located in the U.S. Department of the Treasury, the FSOC is a permanent institution that “has a clear statutory mandate that creates for the first time collective accountability for identifying risks and responding to emerging threats to financial stability” (U.S. Department of the Treasury, 2014). The board of members consist of ten voting members from U.S. financial regulators such as the Treasury, Federal Reserve Board, the Comptroller of the Currency (OCC), Bureau of Consumer Financial Protection (CFPB), Securities and Exchange Commission (SEC), the Federal Deposit Insurance Corporation (FDIC), the Commodity Futures Trading Commission (CFTC), the Federal Housing Finance Agency (FHFA), the National Credit Union Administration (NCUA), and an independent member with insurance expertise. A further five non-voting members give additional support, namely the director of the Office of Financial Research (OFR), the director of the Federal Insurance Office, a state insurance commissioner, a state banking supervisor, and a state securities commissioner.

A declaration on tougher supervision of a single firm can be expanded to a non-bank financial firm if the FSOC sees their own objective of maintaining financial stability threatened. The FSOC can determine a systemic significance if 'material financial distress' emanates from such a non-bank firm or its "nature, scope size, scale, concentration, interconnection" and mix of the activities" (Dodd-Frank Act, section 113(a)(2)(G)) give reason to concerns. Such emerging risks are detected by assistance of the Office of Financial Research (OFR).

Section 113(a)(2) of the Dodd-Frank Act set out the risk indicators for which data is collected and analysed.. These indicators can be grouped into quantitative and qualitative indicators. Classic financial indicators like leverage, the extent and nature of off-balance sheet exposures, financial assets and liabilities, especially reliance on short-term funding, build the quantitative approach to gauge the importance of a company subject to the analysis. In addition to these quantitative indicators the FSOC recognizes the importance of qualitative indicators including relationships with other non-bank companies and bank holding companies alike, the relative importance of the company as source of credit for domestic households, businesses, the state, and local governments. The business model is now relevant to supervision as well. For example, it must be clear whether a company's management owns or merely manages the assets that are under their control. A further point of consideration for the work of the FSOC is whether the company already is under the supervision of a "primary financial regulatory" agency. Section 113 of the Dodd-Frank Act provides a non-exhaustive list of indicators provided to the FSOC and further admonishes the Council to consider "any other risk-related factors that the Council deem appropriate" (Section 113(a)(2)(K)).

The authorisation to collect data and the supervision of non-bank companies are two of the six broad aims of the FSOC. The FSOC is also responsible for:

- the regulatory coordination in order to close gaps in the existing catalogue of regulations,

- the coordination and promotion of the co-operation of the member agencies in exercising their duties,
- the recommendations of new regulatory standards, and
- based on their daily experience of supervision and coordination, the FSOC can make recommendations for best practice in exercising the regulatory tasks.

The FSOC does not have the authority to directly undertake measures against the risks it detects. It can give recommendations to the other regulatory agencies and inform the U.S. Congress about where it sees room for improvement for its own mandate to broaden its operating range (Kohn, 2014). Further standing functional committees assist the U.S. regulatory authorities to bring forth discussions to an international level. Functions that deserve attention are for example avoiding the duplication of gathering data from the supervised institutions. For all of the FSOC member agencies the OFR is the hub to request data from. Therefore the OFR is, at least on paper, pivotal to establishing a data sharing point and setting standards for the process of gathering and facilitating data and conducting research on the tools that help promote financial stability.

However, the new regulatory framework faces significant criticism. Policy makers did not seize the opportunity to harness the momentum of political will to renew the system from the bottom to the top. Instead, an efficient comprehensive system has been sacrificed for a fragmented system with too many agencies that perform similar tasks and could have been merged instead. For example financial institutions in the business of investment advisory have to deal with two conduct regulators, the Financial Industry Regulatory Authority (FINRA) which reports to the SEC, and the Bureau of Consumer Financial Protection. It is foreseeable that it comes to a duplication of compliance work (Llewelyn, 2006). Apart from the financial burden on the regulated institutions, it is doubtful that the regulatory system can address urgent concerns of financial stability fast enough. Harold Levy, former director of global compliance at Citigroup, warns that a lack of tough decision-making by regulators could have disappointing results: Regulators must be powerful and allow prosecution of wrongdoings of banks with hefty fines, "[o]therwise, regulation becomes simply another factor in calculating risk and is taken into account in pricing" (Levy, 2014, p. 16). More recently in the 2014 annual letter to the shareholders, Jamie Dimon, Chairman and CEO of JP Morgan Chase & Co, criticises the new regulatory framework the bank is subject to: "I believe our stock price has been hurt by higher legal and regulatory costs and continues to be depressed due to future *uncertainty* [sic!] regarding both" (Dimon, 2015, p. 19). Granted the macro-prudential framework's early stage of implementation, banks have to accustom to more frequent compliance work. Yet, statements such as the above emphasise the monetary costs the regulated subjects face on a micro-level but ignore the non-monetary benefits of a more stable financial system on a macro-level within which the banks operate.

There is a lack of promoting financial stability as a public good that needs preservation and that both the regulatory authorities and the regulated institutions must co-operate. However, the US authorities are more concerned about themselves. The fragmentation of regulators increases the possibility that information sharing is not optimal and inconsistencies maintain. Admittedly, the agencies are currently in the process of adapting to the new regulatory framework and their roles within it. At the end of this process the individual agencies must open up to and co-operate with their peers. The FSOC encourages to "explore best practices for data sharing and improving reporting efficiency" (FSOC, 2015, p.14). They may be reluctant to share their information on a timely basis and perhaps compete for authority over the regulated industry. This risk of "inter-agency rivalry and disputes" (Llewelyn, 2006, p. 12), also called "turf wars", should remain an objective on the agenda for improving the regulatory architecture and improve conscientiousness.

However, in practice frictions among the regulatory agencies can be observed. In her speech Kara Stein, Commissioner at the Securities Exchange Commission, unreservedly addressed the regulatory agencies' competition to the detriment of the common mission:

> "[M]embers of the FSOC are merely trying to dictate to, or control, regulators with primary jurisdiction over certain areas. The FSOC needs to come together as a team to focus and provide mutual support. And, I fear that individual members defending their territorial jurisdiction detracts from the FSOC's critical mission to promote financial stability" (Stein, 2014).

In an related article in The Economist Jonathan Macey of Yale Law School notes that the Dodd-Frank Act is not directed at people but bureaucrats and "instructs them to make still more regulations and to create more bureaucracies" (Economist, 2012). In the same article The Economist asserts that the Dodd-Frank Act is too big not to fail. Its sheer size introduces a complexity due to "exceptions and nuances" that could "exacerbate systemic risks rather than mitigate them".

3.4.3.3 Interim observation on the regulatory change in the USA

Eventually the Dodd-Frank Act introduces a new regulatory framework to the USA. Similar to the UK, the USA preserves its sovereignty over its regulatory agencies. The multitude of regulatory agencies follows an institutional approach. However, prudential and conduct regulation are exercised by different agencies, too. For example the Securities and Exchange Commission supervises securities-related business conduct through the FINRA; the U.S. Commodity Future Trading Commission supervises derivatives-related business conduct. If a single customer wishes for a mixed investment, the financial institution must comply with both regulatory agencies leading to higher compliance costs.

The regulatory architecture in the USA increases competition among regulatory agencies. In terms of fairness this system has to prove that it can equally enforce their regulatory objectives among banks. The Dodd-Frank Act is explicit and addresses financial operations exercised by banks and non-bank companies that could be sources of systemic risk, i.e. SIFIs and FMUs, respectively. However, the Act accumulates to a lengthy document with 13,789 pages (Davis Polk, 2013). With its sheer size, critics point out that the Act is not a comprehensive piece that clearly defines the regulatory objectives and how to achieve them (Makow, 2011).

Furthermore, conscientiousness is negatively affected by the current stage of establishing the new structure. The agencies could prioritise sharpening their own profile and influence within this regulatory community, see Stein (2014) above, over serving the public. This web of agencies and authorities is reason for confusion among the regulated subjects.

The regulatory approach is effective if the regulatory agencies enforce the rules consistently without hesitation. The Dodd-Frank Act changes the structure of the banking system in the USA and the regulatory community as well. The single regulatory agencies might be effective within their scopes but the whole approach is lacking effectiveness in the bigger picture. The institutional approach does not allow the regulatory community to catch up with the latest developments since *activities* that can be of systemic relevance are exercised by financial institutions that do not fall on the pre-defined list of regulated *institutions*. For further critique on this approach of the Dodd-Frank Act see Acharya *et al*. (2010).

Ironically the Act aims at reducing the complexity of the financial system but increases the complexity of the regulatory community (The Economist, 2012) and the rulebooks financial institutions have to abide by. The Act itself is too big and leads to excessive bureaucracy and in the late stages of drafting several amendments were made that lacked serious debate and could be the very source of future instabilities (Barr, 2011). Concerns that the regulated subject would lobby the amendments to their own benefit did not turn out to be a problem. The opposite happens. The policy makers zest for action resulted in a rushed process of drafting regulations that leave doubt about the framework’s effectiveness.

The regulatory agencies must be granted a phasing-in period to familiarise with the new operational framework. However frictions remain. Time and energy will be wasted on being too occupied with solving internal disputes about responsibilities and sharing resources instead of focussing on the original raison d'être: promoting financial stability.

3.4.4 Regulatory change in the European Union

This section analyses the regulatory framework in the EU. The framework is further divided into the new regulations banks have to abide by and the architecture of the regulatory agencies in the EU.

3.4.4.1 Regulatory action in the European Union: Between the UK and the USA

As of spring 2016 there are no regulatory actions that change the organisational structure of banks[3] so fundamentally as in the UK and USA. Yet the 2012 report of the high-level Expert Group on reforming the structure of the EU banking sector (2012) chaired by Erkki Liikanen, henceforth the Liikanen report, does the groundwork for future legislation of banking industry in the EU. Eventually the European Council drafted a proposal “on structural measures improving the resilience of EU credit institutions” (European Commission, 2014).

The proposal combines ideas for structural reforms from the USA and UK but does not match the actual reforms in scale. A proposed prohibition on proprietary trading as in the USA with the Volcker Rule applies to banks that fall under the definition of article 3 of the proposal. These are deemed global systemically important institutions or are sufficiently large with total assets amounting to at least EUR 30 billion, or display large trading activities exceeding EUR

[3] The European Union legislation uses the term ‘credit institution’, however for the sake of consistency this thesis uses the term ‘bank’. Credit institutions are defined as the business of taking deposits or other repayable funds from the public and to grant credits for its own account, see Article 4 1. (1) of Regulation (EU) No 575/2013, also known as Capital Requirements Regulation (CRR).

70 billion, or 10 per cent of its total assets. A separation of certain activities as in the UK with the ring-fence is proposed, yet the final decision should remain with the national authority, i.e. regulatory agencies in the member state. They review whether the trading activities of a certain bank pose a threat to its deposit-taking business (Article 9) and henceforth the EU financial system. If so, the national regulatory agency can instruct the bank not to carry out these trading activities (Article 10).

Besides organisational reforms on banks the foundation for further regulatory actions in the EU is the implementation of the Basel III accord. Consequently these regulatory standards are transformed into a Single Rulebook. The Single Rulebook ensures a harmonisation of prudential rules applied to the banks and national supervisors across the EU. Since Basel III is not legally binding itself, the EU implements parts of it through the Capital Requirements Regulation (CRR)[4], the Capital Requirements Directive (CRD IV)[5], and the Bank Recovery and Resolution Directive (BRRD)[6]. The CRR gives the definitions and scope of the regulations. The Regulation clearly defines the prescriptive rules the regulated banks have to abide by, most notably the definition of capital and the minimum capital a bank has to produce. The CRD IV is supplemental to the CRR and assists national legislators in implementing the regulations of the CRR into national law.

Ultimately it is the goal to set the capital requirement to a level-playing field for the whole for the EU. No member state should independently increase the capital standard for its banks. Otherwise the threat would be that the affected bank would circumvent this requirement by moving to another member state. So, arbitrage must be avoided with one standard applicable to all banks. However, an exception can be made based on the outcome of an individual supervisory review. The current state of the implementation of CRR/CRD IV grants the member states options and national discretions concerning several key aspects. For example, not all member states impose systemic risk capital buffers on their banks through the legislator or the national supervisory authority. A comprehensive list of which member state uses what option can be obtained through the EBA website. For example, the PRA in the UK does have the permit to introduce such a buffer, but it will come into effect in 2019 at the earliest. In addition to the standard capital requirement capital buffers give some flexibility to increase the loss-absorbency of banks conditional on the state of the financial system. Chapter 4 analyses how macro-prudent these dynamic capital surcharges are, especially to answer the two research questions of this thesis whether first, the incentives of banks are geared towards

[4] Regulation (EU) No 575/2013 of the European Parliament and of the Council.
[5] Directive 2013/36/EU of the European Parliament and of the Council.
[6] Directive 2014/59/EU of the European Parliament and of the Council.

macro-prudence and, second, whether the particular tool can mitigate systemic risk as it materialises. Furthermore, the identification of the systemic significance of a bank is a major challenge in the supervisory review by a national authority. Chapter 5 deals with the conditional Value-at-Risk measure that is specifically geared to measure the systemic risk contribution of a particular bank to the banking system of which it is part of.

Cleaning up bankrupt banks was a messy task in the aftermath of the crisis of 2008. It required substantial use of tax money to bail out banks. The BRRD addresses this issue. The minimum capital requirements and dynamic capital surcharges of the CRR/CRD IV may not be enough to prevent single banks from failing. In fact, avoiding a failure of a bank is explicitly not a regulatory objective. So, if a bank must be resolved, i.e. it is a gone-concern, it must happen in an orderly manner, especially if these gone-concerns can drag down other banks. Also, a bank must not necessarily go bankrupt to cause disruptions in the financial system of which it is part of. This is called a going-concern bank. Currently, the BRRD only sketches the tools and legal grounds to recover a struggling bank that is not a gone-concern but remains a going-concern. Paragraph 85 of the BRRD refrains from from prescribing the exact tools. Nevertheless, chapters 6 and 7 contain a comprehensive analysis and a concrete proposal, respectively, to make CoCos a macro-prudential tool to help recover or resolve a bank.

The BRRD stipultes that the regulatory authorities can request banks to provide them with recovery plans at least on an annual basis, if necessary more frequently (Article 5 of BRRD). These include information about 20 items, see annex of the BRRD, such as:

- how the bank would manage negative market reactions,
- what the critical functions of the bank are,
- how the bank intends to ensure the continuous functioning of its operations (for example how disruptions of the IT services could threaten the core services to the public), and
- how the bank intends to prepare a timely recapitalisation once the recovery plan is executed.

In addition to recovery plans, resolution plans should address the possible threats that stem from the bankruptcy of the bank. The national resolution authorities, fpr example central banks, need at least information about *inter alia*:

- direct holders of the bank’s equity with their respective voting rights,

- material assets and liabilities that are allocated to the core business and critical operations of the bank,
- details about the organisational structure of the bank, including all subsidiaries, and
- possible liquidity sources for supporting the own resolution.

It is important that the agencies tasked with the recovery and resolution can make the banks provide them with hard facts abouts the organisational structure and legal interconnectedness to other financial institutions. Soft factors like "possible" liquidity resources are determined by what the financial markets allow for. This rounds up the agencies' impression of the bank as a whole rather than taking such factors at face value. Suppose that a recovery or resolution plan comes into action at the peak of a crisis similar to 2008. Adverse external financing conditions are hard to anticipate, see the case of Northern Rock in chapter 2. Nevertheless, these repoting requirements help foster awareness among the banks' senior management to show foresight and cater for the worst case scenario. Re-introducing responsibility is certainly paramount to disciplining banks to abstain from unsustainable business conduct.

3.4.4.2 Architecture of the regulatory agencies in the European Union

The current state of the regulatory architecture among the member states of the EU is closest to a global regulatory framework, compare the third and fourth stage as discussed in section 3.3. Since late 2014 the ECB is in charge of directly supervising the 122 largest European banks – likely to be increased to 130 in 2016 (Nouy, 2015) – under the Single Supervisory Mechanism (SSM) (ECB, 2014). The supervision of the other smaller banks remains with the national authorities. The SSM fosters the convergence of supervision across the member states. As of 2016 the ECB co-operates with the national central banks (NCBs) of the states that adopted the euro as currency, they build the Eurosystem. Slightly different is the concept of the European System of Central Banks (ESCB). The ESCB comprises of all EU member states, including those that have not adopted the euro as currency, nevertheless co-operate with the ECB.

The European System of Financial Supervision (ESFS) is the overarching forum for the supervision of banks in the EU and contains the supervisory authorities (European Parliament and Council Regulation (EU) No 1093/2010). Within the ESFS there are three supervisory authorities: the European Securities and Markets Authorities (ESMA), the European Insurance and Occupational Pensions Authority (EIOPA), and the European Banking

Authority (EBA). The European Banking Authority (EBA) first carries out the objective of maintaining financial stability in the EU. It does so by taking the leading role in the creation of the “Single Rulebook” that helps foster convergence of rules in the EU. The EBA further supplements it with guidance on the implementation of specific rules. Second, it promotes the convergence of supervisory practices.

The main objective of the central banking system is to maintain price stability. In addition to this classic central banking objective of monetary policy, the supervision of the stability of banks is codified in Council Regulation (EU) No 1024/2013.

The ultimate goal is to establish a banking union with the Single Rulebook as the common financial regulatory framework for financial services in the EU. Currently there is “a regulatory patchwork, leading to legal uncertainty, enabling institutions to exploit regulatory loopholes, distorting competition, and making it burdensome for firms to operate across the Single Market” (European Commission 2013, p. 7). Consequently, much needs to be done to improve the fairness of this framework. In order to do so, the first step is the introduction of the SSM. In addition to the currently supervised largest banks this would also include purely domestically operating banks. This development foresees one supra-national regulatory agency at the end of different stages towards the integration efforts in the EU.

Article 4 of Council Regulation (EU) No 1024/2013 defines the tasks conferred to the ECB, including the supervision of banks of the member states and conducting stress tests. The ECB is supposed to have the most expertise in issues relating to macro-economics and financial stability in particular (Council Regulation (EU) No 1024/2013, para. (13)). Since the ECB is more experienced it will ultimately take over the leading role and directly carry out the financial stability objective after the transition phase. Competition between the ECB and national central banks and regulatory agencies are fierce. Paragraph (79) of Council Regulation (EU) No 1024/2013 explicitly requires NCAs to second skilled staff to the ECB. This temporary brain drain for NCAs is compensated by a gain in the long-run. Also, for the relationship between the NCAs and the ECB, staff at the NCAs better understand and accept the overall regulatory objectives for the trans-national supervision of banks and are not only focused on the domestic banking sector, thus improving conscientiousness.

3.4.4.3 Interim observation on the regulatory change in the European Union

The most important regulatory reforms on the EU level on the structure of the banking industry resemble a "light version" of the ring-fence in the UK and a "light version" of the prohibition of proprietary trading in the USA, also called Volcker Rule. The regulated activities can still be carried out, but only within a banking group with a clearly distinct entity like in the UK. Yet, this applies to banking groups larger than EUR 70 billion. Upon a major disruption a regulatory invention is made more practical and a contagion to the rest of the banking group is mitigated.

This contrasts to the structural reform of the banking industry in the USA, where certain activities like hedge fund investments must not be located under the same roof as deposit-taking, the EU restricts certain trading activities in volume rather than prohibiting them altogether.

However, the member states currently do not give up their sovereignty over regulating their banks in full. The competence for carrying out the supervision of small banks remains at the national level. So does the decision about putting certain regulations in place. The ECB and subsequent agencies, at the current stage, aim to improve the coordination among national supervisors. The long-term goal is to promote convergence in the regulations according to the Single Rulebook that would reverse the options and discretions some member states use.

The ECB can use its data collecting powers and accumulation of qualified staff from NCBs to conduct centralised research. The output, in return, is available to the NCBs. The high-quality research with macro-prudential scope on the ECB level resembles the unifying role of the OFR in the USA. There, the OFR collects data from the different regulatory agencies with different scopes (securities, banks financial data, conduct, etc.) to derive a clear picture of the state of financial stability. The ECB also collects data from different agencies but since these are NCBs, they have the same scope; it is merely the same kind of data but from different jurisdictions.

As far as the fairness of this regulatory framework is concerned, the regulations in place do not apply to all banks in the EU. At the current stage of integration, the SSM, under the roof of the ECB, supervises the 122 largest banks in the EU in terms of size. This, in general, would give banks the incentive to stay below the threshold conditions of the ring-fence regulation and proprietary trading restrictions. Also, member states make use of options and national discretions granted within the SSM. There are about 150 items of the CRR/CRD IV that are subject to discretion (Nouy, 2015), which certainly hinders the efforts of convergence. However, the SSM is in its early stage of implementation and these gaps are going to be addressed.

Conscientiousness, according to Dudley (2014) in section 3.4, aims on how the regulatory agency perceives itself; it must be honest about its own work and self-critical analysis must be followed by the willingness towards self-improvement. This is a crucial point and must not be underestimated. The staffing process after the formal introduction of the SSM alongside other departments of the ECB is extensive. Indeed, the competition for staff between the ECB as the single regulator and supervisor in the future and the NCBs can have repercussions. The ECB and the NCBs are expected to co-operate and work towards the common objective. Regardless of the SSM in particular, over the last years tensions have emerged. NCBs understandably have mixed feelings of a mandatory brain-drain to the ECB (Reuters, 2013a). Yet, if the secondments are temporary the long-term advantage is that the average quality in each NCB is increased, hence further strengthening the SSM.

Apart from the regulations and architecture of the regulatory framework, a reason to concern the current status is the discrepancy among staff. One measure to assure the independence of staff is a degree of security for one’s job similar to a civil servant. In fact a significant number of jobs at the ECB across all departments are limited to 12 to 24 months with no guarantee of continuation and subsequently rolled over together with a high workload of the individual member of staff (Wall Street Journal, 2015). If members of staff, especially those that engage with the regulated subjects, are constantly worried about employment, there is an acute threat of capture with negative consequences on fairness and effectiveness. With the prospect of employment at a reviewed bank, the particular member of staff might be less intrusive and passes on a more positive view.

Effectiveness of prudential supervision means that large banks are in the focus of the agencies and supervisors are indeed tough on them, i.e. have the “teeth” and are not afraid to show them. The ECB is in progress of implementing the SSM towards a unified regulatory approach. In the meantime, the most important contribution is, together with the EBA, to encourage the convergence of the Single Rulebook across the member states and assist NCBs in its application. So, the current state of the EU regulatory framework is effective in regards of harmonisation efforts but not yet effective in centralising the direct power to regulate banks to the same degree and on a level-playing field.

3.5 Conclusion and outlook

Financial stability is the new regulatory objective and must be treated as a public good (Shirakawa, 2012). In the years leading to the global financial crisis of 2008, there had been a threat to this public good. Financial stability has been taken for granted and key players put stress on the stability by taking excessive risks. Regulatory agencies contributed to this too. There was a lack of a culture of critical thinking that might have let to challenging the business conduct of banks and the nature of financial risks (Turner Review, 2009). Once markets became unstable, the financial sector could not re-establish stability on their own. Hence the public sector, i.e. national governments had to intervene in this market failure. Ideally, the new macro-prudential regulatory paradigm realises that "markets must sometimes be nudged, pushed, or even forcefully shoved off their existing trajectory so as to prevent them from running into disasters" (Shirakawa, 2012, p.1).

Banks have become "too-big-to-fail, too-big-to-save and too complex to manage, supervise and resolve" (Council of the European Union, 2015, p.1). In this chapter the different approaches of the UK, USA, and EU are analysed to show the different national interpretations of a macro-prudential framework. First, a framework addresses the regulations the banks have to abide by, for example in the form of organisational requirements of how a bank, or banking group, must be organised. Second, the framework considers how the regulatory agencies are organised to serve their regulatory objectives best. This can be a single generalist regulatory agency or several specialist agencies; The former is best suited to supervise certain kinds of institutions like banks, insurance firms etc. (institutional approach), the latter is best suited to supervise certain functions like deposit-taking, securities trading etc. (functional approach).

Recall the two core research questions throughout this PhD thesis derived from the crisis of 2008 in chapter 2. Applied to the new regulations and regulatory architecture in the UK, USA, and EU, the questions are:

- Does the regulatory framework in the respective legislation address the regulated banks' incentives so that they abstain from taking unsustainable risks that can cause a systemic crisis?
- If yet systemic risk emerges, is the regulatory framework in the respective legislation able to limit its potential for further damages?

As for the first question, the regulatory agencies in the UK, USA, and EU are more intrusive than before the crisis. Banks face higher compliance costs due to the pro-activity of the regulatory agencies. For example, banks are required to regularly report their views on the own healthiness and gauge the risk to their core businesses. Unlike to the pre-crisis regulation, there is no “regulatory dividend” to banks. This means that regulatory agencies left banks alone for some time after a satisfactory compliance work (Black, 2015). Unfortnately, this decreased the compliance efforts after the supervisory review. Instead, from now on the regulatory agencies constantly conduct regulatory reviews of banks and developments in the financial system. This, in general terms, increases the chances to detect doubtfull business conduct within banks and challenges the sustainability of certain business models banks employ.

As for the second question, there are mixed results, largely because the UK and EU keep trading and vital banking services in the same organisation, but the USA prohibits this practice. A complete separation bears the threat that destabilising developments in the financial system go unnoticed by a regulatory agency that is only concerned with banks exclusively. As soon as these destabilising effects enter the banking system indirectly, it might be already too late. Within a ring-fenced system such developments can be detected at an early stage.

The UK has come up with a completely new architecture for its regulatory agencies. The FPC is embedded in the Bank of England, the UK’s central bank. The financial industry has to deal with two regulatory agencies that are subordinate to the FPC: a conduct regulator, FCA and a prudential regulator, the PRA. One advantage of this twin peaks model is a clear division of responsibilities of the agencies to hold them accountable for. The organisational structure in the UK provides a reliable framework to fulfil proper macro-prudential regulation.

In the UK those activities that are vital to the economy, like deposit-taking, are planned to be ring-fenced. The “universal banking” model of such bank holding companies, i.e. deposit-taking alongside proprietary trading, is not completely repealed. Instead, a clear line is drawn by moving proprietary trading outside the ring-fenced activities but remain intact within a bank holding company. Further bans on cross-financing the two groups are easier to impose but must be regularly supervised by the regulatory agencies. The advantage over a complete separation, like in the USA, is that the regulatory agenies can still monitor the developments in the financial markets that threaten financial stability.

The EU follows a less strict approach on ring-fencing, making it mandatory only for banks of a certain size. However, the same advanteages of the UK approach applies to the light-version of the ring-fence in the EU.

As for the second question, the ring-fence regulation on banks in the UK and EU specifically address the problem of systemic risk that stems from a failing bank. If a bank fails, the resolution of a bank and the protection of core services vital to the rest of the economy are more practicable. This does not guarantee a perfect mitigation of a crisis. But compared to the pre-crisis times it mitigates the systemic risk of individual banks.

In the EU, a coherent regulatory framework, as codified in the Single Rulebook, is the first step towards a banking union and member states are expected to give up some sovereignty to supervise domestic banks. However, at the current stage the SSM under the ECB leaves the supervision and intervention to the NCBs. The sovereignty of the member states of the EU is not yet significantly diminished. So, to some degree a member state can currently have deviating regulations. For example, the scope of the ring-fence regulation in the UK is much tougher on its banks than the EU version of the ring-fence that only applies to banks of a certain size.

The ECB is a supranational single regulatory agency but the NCBs support it in the task of supervision in the respective member state. Only the largest banks are subject to direct supervision by the ECB. This approach, on paper, is a comprehensive macro-prudential framework. However, deviating national interests give a patchwork picture of the actual state of the SSM.

In the USA the Financial Stability Oversight Council (FSOC) is mounted on top of an already existing body of regulatory agencies. The FSOC is commissioned with the difficult task to manage a voluminous web of regulatory agencies. This results in overlapping responsibilities, duplication of work, and makes it more difficult to hold a single agency accountable.

Competition among the regulators ideally is a process to identify "best practice" and produces good regulation since it avoids group think. However, at the same token overlapping responsibilities lead to turf wars. The agencies are more concerned about protecting their own reason for existence rather than serving the regulatory objective (Blackmore and Jeapes, 2009). Especially in crisis times, the public – including the taxpayer who might have to pay – expects the regulators to take action. An overambitious regulator seeks to overbid other regulators to act immediately to sharpen its profile. Similarly, on a more senior level, premature reactions of representatives of the agencies and policy makers, i.e. politicians serving on the committees for regulatory decisions, can be observed immediately after a crisis (Economist, 2008).

In the USA the Volcker rule prohibits proprietary trading and deposit-taking in the same organisation. The consequence is that financial institutions simply remove those activities that cause systemic risk out of the regulated parts of the financial system. As of 2015 several of the largest banks in the USA, among them JP Morgan Chase and Goldman Sachs, closed proprietary trading desks and wound down those funds that would be affected by the regulations. They leave the field for these particular trading and investment opportunities and it will be taken over by other, less regulated or not regulated parts of the financial system, i.e. shadow banking. The ECB (2015) identifies an increase of such migration and that the shadow banking system contributes to systemic risk in the whole global financial system. In conclusion, new regulations do not directly address the creation of systemic risk but pushes it to somewhere else in the system. So, in contrast to the ring-fence in the UK, and to a lesser extend EU, a complete separation of certain trading activities from vital services to the economy only takes the sources of systemic risk outside the regulatory agencies' reach.

The regulatory agencies can claim a success when a large disruption anywhere in the global financial system does not find its way into their regulated territory. With varying degrees, their mandate enables them to expand their interventionist powers to other sections of the financial system as they see appropriate. The regulators in the USA can designate the status of a "financial market utility" to financial institutions when they see a threat to their objective. Ironically, regulatory discretion introduces a dilemma: On the one hand this gives them the power counter banks' and other certain financial institutions' incentive to arbitrage as they can follow the sources of systemic risk. On the other hand this freedom to do so increases the expectations of the public that the regulatory framework avoids crises altogether. This might discourage the regulatory agencies to be too intrusive to the benefit of their own credibility.

In conclusion, the current structure in the USA does not provide a credible degree of effectiveness. Because of its potential for inner conflicts in the form of inter-agency rivalry, i.e. turf wars, the organisational structure in the USA does not provide a reliable framework to fulfil proper macro-prudential regulation.

The macro-prudential tools at the regulatory agencies' disposal must follow a holistic approach. Ideally, a macro-prudential regulatory framework "should address the root causes rather than merely the symptoms of instability" (Large, 2011, p. 206). The new regulatory agencies must show that they are able and more committed to catch up with developments in the banking sector than they were before the financial crisis of 2008. The next chapter discusses the macro-prudential tools to achieve this.

4 Macro-prudential tools

The previous chapter shows how the new regulatory agencies are designed. This chapter focuses on some of the tools in the toolkit at their disposal.

4.1 Introduction

Regardless of how the regulatory agencies are structured – whether one regulatory agency, a twin peaks approach, or a plethora of agencies – this chapter analyses the tools the agencies are generally able to employ in order to fulfil their regulatory objectives. Not all regulatory agencies use these macro-prudential tools equally or at all.

The shift towards macro-prudence does not only comprise a change in awareness of how systemic risk works (chapter 2), reshaping the regulatory agencies to address the challenge of systemic risk (chapter 3) but a set of specialised tools is necessary too. The tools at prudential regulator's disposal are the subject of this chapter.

This chapter analyses some the core tools that regulate the capital requirements, leverage, and lending business of banks. An overview of the macro-prudential toolkit can be obtained in Claessens *et al*. (2013). Further auxiliary tools are the use of living wills and contingent capital. Living wills are discussed in the context of the ECB's recovery and resolution powers, the BRRD, in section 3.5.4.1 of the previous chapter and need not be repeated here. Contingent capital finds brief mentioning here but is subject to an in-depth qualitative analysis in chapter 6 and a quantitative analysis in chapter 7.

The case for new macro-prudential tools is that they avoid the collateral damages that can come when traditional monetary tools are exhausted to address issues of systemic risk. The macro-prudential tools complement monetary policy (Hannoun, 2010). Therefore the macro-prudential regulatory agencies must be close to the monetary decision makers to coordinate. So, in addition to the findings of the previous chapter, a further advantage of the twin peaks model employed in the UK is that the PRA under the guidance of the FPC is located within the Bank of England.

For example, during and after the global financial crisis of 2008 central banks around the world had to pave the way out of the recession. They decreased the interest rates to historical low rates to encourage banks to give out more loans to the economy and stimulate growth. Before the crisis central banks' objective is to maintain price stability as indicated by a concrete annual inflation rate of 2 per cent. For example, in the years before the crisis the

Bank of England has met its inflation target. However, as a consequence the balance sheets of domestic and international banks grew rapidly and the Bank of England conclude that "[m]onetary policy would not have been able to curb these emerging financial imbalances without diluting the commitment to its inflation objective" (Bank of England, 2009, p. 10). A change in monetary policy to lean against a bubble with increasing interest rates can have adverse consequences in other parts of the economy to the point that the economy's output, Gross Domestic Product (GDP), decreases (for empirical evidence see Assenmacher-Wesche and Gerlach, 2010).

The inherent procyclicality of the financial system can result in financial instability. In economic upswings financial markets underestimate risk and ignore the time dimension of risk (Borio *et al*., 2001). This means that market participants do not factor in the incentive of other market participants, such as banks, to load more debt on their balance sheet in order to produce even more lending. Banks do not raise their equity cushion in economic boom times when equity is cheapest. In the economic downturn they must raise equity when it is just needed. Now markets change their perception of banks riskiness, quite likely to overestimate it if they see that the banking sector as a whole is in financial distress. Consequently the banks compete for equity at a premium.

Regulatory agencies now have the tools that allow them to lean against this procyclicality instead of cleaning up after procyclicality caused a crisis. The macro-prudential tools that are currently available manipulate the liability side of a bank's balance sheet and affect banks in their lending decisions. The former can be separated in those tools that manipulate the capital requirements and the newly discussed idea of contingent capital. Interfering in the lending decisions is the most severe intervention through a regulatory agency but offers the most potential for addressing the building up of bubbles due to unsustainable credit growth.

Section 4.2 deals with regulating capital requirements as one tool of regulating the liability side of the balance sheet. Higher capital cushions are important loss-absorbing resources in the case of financial losses. This abates the threat of a bankruptcy of a bank. Furthermore, the leverage ratio is the second side of the same coin and is discussed in the same section.

Section 4.3 focuses on regulatory intervention on the asset side of a bank. At times, regulatory agencies can impose limits on the issuance of loans with certain ratios such as loan-to-value (LTV). Among others, such ratios determine the riskiness of individual lending contracts.

Section 4.4 presents auxiliary tools in addition to the previous "core" macro-prudential tools with which regulatory agencies can lean against the building up of bubbles. Ill-aligned bank managers' remuneration is on the regulatory agenda to counter short-termism. Also contingent capital is briefly sketched as this topic is analysed in chapters 6 and 7. Section 4.5 concludes and answers the research questions.

4.2 Tools to regulate capital

Raising capital requirements is the regulatory agencies' tool to internalise systemic risk and bolster loss-absorbency against an imminent shock in the financial system. These requirements are further divided into countercyclical buffers to mitigate systemic risk in general and sectoral buffers to dampen risk coming from specific sectors, especial residential and commercial property. This makes the regulated banks more robust but not necessarily the rest of the financial system.

The example of the UK policy makers are chosen simply for illustration purposes. The FPC can impose sectoral capital requirements (SCRs) and countercyclical capital buffers (CCBs) for specific financial institutions in the UK (Tucker, 2013; FPC, 2014). Both tools increase the capital standards above what a purely micro-level assessment of the particular bank would suggest is the appropriate level. The SCRs aim at developments in sectors that are "judged to pose a risk to the system as a whole" (FPC, 2014, p. 5). Concretely, these sectors are mainly the financing of residential and commercial property.

The CCBs are the tool of choice to abate the systemic threat that concerns all loans given out to borrowers in the UK. The SCRs on the other hand address threats stemming from other specific sectors that are not domestic lending. The total countercyclical buffer a UK bank has to produce is proportional to its mix of domestic and foreign exposure. For example, if the CCB rate is 1 per cent and foreign is 2.5 per cent and a bank holds 50 per cent of its loans in the UK and 50 per cent in foreign markets, its specific buffer is $1 \times 0.5 + 2.5 \times 0.5 = 1.75$, or 1.75 per cent (Bank of England, 2013). The CCB and SCR address the same threat but are complimentary for they either defend against systemic risk that already is in the financial system or abate systemic risk that comes from a specific sector, respectively (Korhonen, 2013).

However, capital requirements that are derived from developments in asset prices in certain sectors, such as commercial property, are difficult to justify. Central bankers' are bound to price stability but then again should, and after the 2008 crisis indeed have, the task to lean against bubbles before they burst and spread into panic. It is difficult, if not impossible, to clearly identify a bubble *ex ante*. A significant increase in the price for certain assets can be due to a change in fundamental factors, non-fundamental factors, or a combination of both (Bernanke and Gertler, 2000).

For example, assume that the prices for commercial property in a certain region increase by 20 per cent within a three months period. It is not a bubble if this growth is the result of a relocation of businesses to this region, i.e. a fundamental change. It can be a bubble if investors, who are looking for short-term profits, observe the relocation of businesses and also purchase properties and so further fuel the price increase. The local businesses could contribute only, say, 15 per cent of the price increase and speculation the other 5 per cent. The difficulty is to identify the non-fundamental portion of such price increases that can become dangerous speculation. The economic theory behind hedgeing, speculation, and Ponzi-like stage of markets are explained in greater detail in chapter 2. Given the difficulties of identifying bubbles and the limits of the monetary policy toolkit before the crisis, it was better to let bubbles burst and clean up the consequences (Allen and Carletti, 2013).

Recall from chapter 2 the excessive “originate to distribute” model that led to the U.S. sub-prime crisis and consequently the global financial crisis of 2008. The increased capital buffer requirements would have produced more loss-absorbing capital against the shock. However, higher capital requirements do not address the lending decisions of banks directly. A countercyclical capital buffer is too general. Banks would see that the regulatory agencies are concerned with systemic risk, but a decision whether to wind down their own mortgage securitisation business remains unaffected. Minimum capital requirements can increase the stability of an individual bank simply because it is more likely to survive a distortion in the financial markets. So, the riskiness of the bank is decreased hence investors would require a lower rate of return on their stake in the bank (Admati and Hellwig, 2013) However, recall from section 3.4.1 the reluctance of bank managers to embrace regulations that aim at reducing social costs that stand in contrast to the return on equity, the main measure of bank performance (Moussu and Petit-Romec, 2013). Bank managers will treat mandatory higher equity holding as what it is in their opinion: a cost factor. More regulatory capital will help fulfil the regulatory objectives but is unlikely to introduce a cultural change of taking risks. Addressing the incentives must be a crucial part of the paradigm shift toward macro-prudence.

A thorough application of the CCB and SCR among the financial sector is crucial to avoid the possibility for regulatory arbitrage. The FPC caters for this issue by recommending HM Treasury to grant an extension of the FPC's reach (HM Treasury, 2012). The list of institutions to which the macro-prudential tools currently apply (see Bank of England, 2013) can be extended beyond banks, building societies, and large investment firms incorporated in the UK to small and medium-sized investment firms if concerns of risking financial stability are evident. Hence, the concern of regulatory arbitrage can be abated. Regulatory agencies in other jurisdictions must have the same degree of freedom to request an extension of their operating range.

Another macro-prudential tool is the manipulation of the leverage of banks. The recommendations for leverage ratios are, in analogy to capital requirements, set out in Basel III in an effort for global harmonisation. The leverage ratio is complementary to capital requirements with a crucial difference: The capital requirements are risk-weighted, leverage is not. The weighting of risk is difficult especially in regards to the volatile nature of systemic risk. A proposal for measuring systemic risk is subject of chapter 5. The previous chapters show that banks have incentives to interpret the applicable formulae for risks according to their individual preferences, i.e. decreasing regulatory capital based on risk-weighted assets. However, additional risk-independent leverage requirements serve as an additional "backstop" (BCBS, 2014).

Manipulating the leverage ratio of financial institutions will be phased in from 2016 (FPC, 2015a). Three different ratios are planned: The minimum leverage will be applied to all PRA-regulated institutions. This sets the absolute minimum to prevent the risk that internal rating methodologies fail to produce appropriate risk-weighted capital. Second, additional leverage ratio buffers aim at the distribution of risk within the financial system and indicate systemic risk to global systemically important banks (G-SIBs). The third leverage tool is the countercyclical leverage ratio buffer. This tool introduces an additional flexibility in assigning a systemic risk buffer. For example credit growth is subject to cycles. In times of a soaring credit growth, especially when it is unsustainable, the buffer increases and relaxed when growth is moderate.

4.3 Tools to regulate lending

This section focuses on the tools that influence the lending side of a bank and therefore interfers in the business decisions of a bank. Borio (2011) defines the success of a macro-prudential tool by its ability to dampen the upswing movement of a financial cycle during which systemic risk accumulates. So, the particular tool serves as a "speed limit" (Borio 2007, p. 5). This aims at introducing a countercyclicality that aims at leaning against excessive credit expansion, which most likely comes with unsustainable risk-taking on part of the banks. Obviously, avoiding the building up of a boom must start with the lending decision to the individual mortgage borrower. For this the following ratios should be determined with prudence: the loan-to-value (LTV), loan-to-income (LTI), and debt-to-income (DTI). All of them are complimentary.

The LTV ratio compares the value of a mortgage to the value of the house. For example if the house is valued at US$ 100,000 and the mortgage is US$ 80,000, the loan-to-value ratio is 80 per cent. The mortgage taker can be required to pay the other 20 per cent with own equity. It is important to ensure that the mortgage taker does not game the rules by raising debt elsewhere and declare it as equity. Otherwise the mortgage would be 100 per cent debt-financed, which increases the chances that the mortgage taker defaults if the annual rates increase. Hence, at the same token the mortgage lender must conduct due diligence background checks on its customers to avoid this scenario. Gerlach and Peng (2005) investigate the housing market in Hong Kong. They find that a LTV of 70 per cent is a prudent level, so that a sharp decline in the housing sector has less an effect on the stability of the banking sector.

A further prudent measure within a bank's due diligence is the LTI ratio. The LTI compares the particular mortgage to the overall income of the borrower and indicates the constraints the mortgage would impose on the borrower. So, household indebtedness in the form of NINJA loans, that fuelled the U.S. sub-prime crisis, would have been curbed. In 2014 the FPC recommended to the PRA and FCA to ensure that lenders are constrained to give out no more than 15 per cent of their total number of new residential mortgages at a LTI of 4.5 or higher (FPC, 2014a). However, this constraint only applies to lenders with mortgage lending worth more than GBP 100 million per year. The excess demand for high LTI ratio mortgages is served by smaller lenders. This recommendation helps avoid a clustering of such high risk mortgages around a few lenders that dominate the mortgage business and would otherwise scoop the vast majority of demand.

An accompanying measure is the DTI ratio which measures, independent from the price of the property and the mortgage on offer, the overall indebtedness of the borrower. The difference between the DTI and LTI is that the former is a ratio of all of the household indebtedness and the LTI ratio reflects just how much of a financial commitment the mortgage loan is to the mortgage taker.

Similarly, the DTI limits the proportion of mortgages a lender could give to households with a relatively high indebtedness, as indicated by the ratio of debt to income. Such limits would not have avoided a sub-prime market for mortgages in the USA, which is not the point, but would have avoided an unrestricted *growth* of such a market. Further restrictions on the amount of high LTI ratio mortgages each bank is allowed to issue avoid that the growth of such markets are in the hands of few institutions that can eventually become systemically relevant. If identified early, the growth of such a market can be restricted before its collapse is sufficiently big to spark systemic risk.

For example, in 2014 the FPC identified instabilities in the UK housing markets (Bank of England, 2015). In accordance with the Chancellor of the Exchequer, the FPC recommended that the HM Treasury uses its statutory powers to enable the FPC to task its subordinated regulatory agencies, the PRA and FCA, to limit the regulated lenders in their mortgage business. The macro-prudential tools with which the limit was imposed were the LTV and DTI. Igan and Kang (2011) find empirical evidence that limits on LTV and DTI do curb property speculation in the first place.

The higher the various ratios are, the riskier is the mortgage to the issuing bank. So, those households that take mortgages but have a small income are offered mortgages with high LTV ratios. If in addition, as seen in the U.S. sub-prime business, additional mortgage insurance is bundled, the customer can not reasonably be expected to pay back in full. Nevertheless, the "originate-to-distribute" model intended to securitise the mortgage. If a strict regime of LTV, LTI, and DTI ratios was in place, this business practice could have been avoided. Hence, low quality mortgage-backed securities, that eventually became toxic, would not have been distributed to the financial system in high volumes. This is exactly how to lean against a bubble, instead of cleaning it up afterwards.

4.4 Further possible regulatory tools and powers of the regulators

In addition to the core macro-prudential tools this section illustrates two more promising auxillary macro-prudential tools, i.e. contingent capital and bank manager remuneration.

4.4.1 Contingent capital

A promising avenue for regulating the liability side of banks is the use of contingent capital. This topic receives more attention in chapters 6 and 7. There are several issues depending on the design features of contingent capital. Chapter 6 identifies these by reviewing the existing body of literature and identifying problems. However, chapter 7 proposes a design that circumvents the most pressing problems.

In short, contingent capital aims to boost a bank's capital cushion when needed. Of course due care must be exercised in determining the terms and conditions of such capital. What is basically done is that debt is either written down in the bank's books or is converted into equity upon a trigger event to increase the loss-absorbency of the bank.

Also the design of the trigger event plays an important role. For example, conversion can be exercised automatically if the capital ratio falls to a dangerously low level of, say, 5 per cent. Alternatively the regulatory agency in charge can be equipped with the discretion to pull the trigger. This, of course, would require the agency to have a comprehensive opinion on the systemic risk threat stemming from the particular bank.

Because of the alternative design features it is sensible to be clear on the terminology. If the decision to trigger rests with a regulatory agency, such contingent capital is also called bail-in capital. Effectively, creditors are bailed-in by a public authority and face a total loss or a haircut on their pecuniary claim in a bank. In the case of a haircut, there are two scenarios. The write-down can be permanent or, if the bank recovers, can be written-up again to the initial face value of the debt claim.

If on the other hand the conversion is not triggered by regulatory discretion but a previously defined and contractually agreed event, the name contingent convertible (CoCo) applies. The most interesting scenario is the conversion of the debt claim into newly issued equity. The idea is that if a bank's capital ratio falls below some ratio that is deemed too low, then the CoCo investors are repaid in new shares of this bank. The loss-absorbency is boosted instantaneously and therefore saves precious time to resolve the financial distress of the bank.

Then again, why would a creditor agree to have his debt claim wiped out and be compensated with equity of a bank that is in distress? The answer depends on the terms of conversion that are discussed in more detail in chapters 6 and 7.

4.4.2 Bank management remuneration and retaining earning

This sub-section discusses the limits of capping bank managers' remuneration that ought to set incentives to abstain from short-termism. The UK Commission on Banking Standards (2013) propose to get the balance of costs and benefits of risks right. Banks set the remuneration of their staff, but the regulators must critically inquire firstly whether the financial success justifies remuneration figures and secondly from what part of the banks' business areas the success comes from. For example, the regulators – now looking through a macro-prudential lense – must be wary of banks making non-sustainable short-term profits, threatening financial stability on a macroeconomic level. Furthermore, dealing only with financial figures of the entire bank could be misleading. Imbalance among the different business areas could lead to cross-financing loss-generating areas. Nevertheless, the ring-fence of certain activities proposed in the UK and EU assist the agencies to detect such imbalances.

The actual plans are found in a joint Consultation Paper of the PRA and FCA (PRA, 2014c). There, the aim is to curb excessive risk-taking and short-termism in order to incentivise bank managers to employ more serious and effective risk management systems. Those members of bank staff face the consequences for wrong doing in the form of either a clawback on already paid bonuses or a deferral of bonuses.

A clawback means that already paid remuneration in the form of bonuses is paid back to the bank if the PRA sees a violation of conduct. A deferral is a current halt on variable remuneration. For example, if a bank requires public aid in the form of tax money, bonuses are withheld. These rules apply not only to the senior management but also to relevant managers that are junior in the hierarchy. If the PRA sees it appropriate, senior managers' bonuses can be deferred up to seven years and up to five years for other material risk takers like risk managers. The period for *ex post* clawbacks is up to ten years for senior management and seven years for other material risk takers.

The powers to manipulate the incentives of senior management and staff are a crucial part of the regulatory agencies' tasks. Focussing on the incentives of individuals instead of taking a firm-level view allows for severe repercussions for wrongdoing. The aim is to promote prudence by reinforcing personal accountability.

In general terms, aligning the returns with the risks taken should be a fundamental guide for taking sustainable risks. Chapter 2 shows how the incentives were distorted prior to the crisis by decoupling the long-term risks of issuing mortgages from the returns, which were made liquid and paid to the banks almost instantaneously. This must be corrected. However, doing so through regulatory agencies that can punish managers *ex post* is not optimal. Critics of capping bonuses hint to the threat that banks simply decrease variable pay and increase fixed remuneration (EBA, 2015). Also, if drawing the consequences, i.e. a financial impairment, comes years after the initial misconduct, it is arguable whether the particular individual actually experiences a learning effect. Chapter 7 proposes CoCos as an alternative to retained remuneration in order to reinforce personal accountability of bank managers.

4.5 Conclusion and outlook

The capital requirements in the form of SCRs and CCBs are risk-weighted measured in absolute values. A necessary accompanying regulation is the imposition of leverage requirements. Both requirements are liability side regulations tools. The leverage is the ratio of capital, especially high quality equity, to other debt. An increased CCB for example does not completely insulate a bank from distress.

Those macro-prudential tools have a potentially higher impact than traditional monetary policy tools that affect the economy by large. This is largely due to their focus on adjusters on the micro-level. Therefore the macro-prudential regulation exercised by regulatory agencies can be renamed "systemic policy", which is complementary to classic "monetary policy" exercised by central banks (Large, 2011). Monetary policy can focus on the traditional central banking objective of maintaining price stability. The systemic policy promotes the second objective of maintaining financial stability by means of various macro-prudential tools.

Systemic policy can avoid the build-up of unsustainable businesses in the first place, which can be the potential source of systemic risk, by imposing restrictions on the lenders. For example, mortgage loaning banks can only hold a specific portion of their total newly issued mortgages which have a specific risk structure. This structure is expressed in the Loan-to-value (LTV) ratio and Loan-to-income (LTI) ratio. High LTVs mean that the majority of a property's value is financed with a mortgage, i.e. the mortgage taker is highly leveraged.

Lower LTVs require the mortgage taker to bring own equity. The LTI accompanies the LTV. Low ratios aim at preventing household indebtedness.

The regulatory agencies can interfere in the lending decisions by rationing high risk mortgage lending. This avoids incentives for arbitrage, because it is not a complete prohibition on high risk lending, as indicated by high LTI and LTV. With these tools the creation of systemic risk stemming from lending to the real economy is dampened in the first place rather than somehow managed after it was already within the financial system.

However, large sized firms that are bank customers are not exclusively dependent on funding through credit intermediation performed by banks (Park, 2011). Given their size, they can raise funds by issuing bonds and other obligations directly in the global capital markets. They would do even more so the tighter the regulatory agencies adjust the macro-prudential tools. Higher capital charges on loans with the aim of dampening exuberance in asset growth would discriminate against smaller firms that do not have direct access to capital markets as an alternative source of funding. Also, turning to other sources of funding in less regulated parts of the financial system can again lead to systemic risk concerns.

As mentioned earlier in the introduction each chapter is set to address the two research questions identified in chapter 2. Therefore, the following discussion aims to answer:

- Do these macro-prudential tools encourage sustainable risk-taking?
- Do these macro-prudential tools curb systemic risk when it materialises?

As for the first question, the regulatory agencies can manipulate the capital requirements of banks through sectoral capital requirements (SCRs) and countercyclical capital buffers (CCBs). This, in general, should affect the risk appetite of banks in the lending decision of the respective sector. For example, the unsustainable lending practices in the U.S. sub-prime mortgage sector are likely to have not occurred with such a SCR. If the central bank had identified a bubble in this sector and had leant against it by raising the capital requirements for residential mortgages, issuing such mortgages would have been less profitable – if profitable at all. However, taking such a macro-prudential view poses a challenge to the regulatory agency in charge of the deployment of the tool. The difficulty is to determine the existence of the specific sectoral bubble. Countercyclical buffers are raised in financially tranquil times in order to avoid exuberance in excessive credit growth; the buffer is relaxed in the downward movement during a recession to stimulate lending. So, compared to the pre-crisis cyclicality of booms and busts, the peaks are damped in order to make the downswing less severe.

A cap on the remuneration of managers at pivotal points in the bank and the more senior level hit the management personally. If individual misconduct can be proven, forfeiture or at least deferring bonuses is an appropriate tool to incentivise managers. A retrospective punishment through a clawback of already paid bonuses would, in general, push managers from short-termism towards foresighted risk-taking. However, if wrong-doing is revealed and punished years after the incident, then the incentives towards sustainability might not be as high as hoped for.

As for the second question, SCRs and CCBs apply to banks as the regulated subjects. The rest of the financial system, i.e. shadow banking system, is less regulated. There is the threat of arbitrage. Certain businesses that would be subject to SCRs when performed by banks can simply be taken over by other, less regulated financial institutions. For example, the ECB (2015) warns that disintermediation in the banking sector is happening and that other players in the financial system are taking over the credit intermediation that was previously performed by banks.

In conclusion, banks are incentivised to abstain from certain businesses that the regulatory agencies consider a source of systemic risk. So, the individual banks are less of a systemic risk concern. However, banks are still exposed to possible adverse refinancing conditions in the financial system, as the case of Northern Rock shows.

In contrast to the specific sectoral requirements, the leverage ratio is not a risk-weighted capital requirement but an absolute threshold. The maximum leverage is determined by the regulatory agency similar to the countercyclical capital buffer. A prudent level of leverage increases the loss-absorbency of a bank in general. Consequently, regardless of where systemic risk emerges banks with more prudent leverage ratios are better equipped in dealing with financial distress.

In conclusion, the various macro-prudential tools individually address problems of incentives and systemic risk. No single tool can address every problem equally. So the tools are complementary and should be part of a holistic toolkit at the regulatory agency’s disposal.

Curbing systemic risk necessitates that the regulatory agency can identify systemic risk, ideally in its early stages. The different measures of how to spot systemic risk well before it accumulates to concerning levels is the subject of the next chapter.

5 Conditional Value-at-Risk as a systemic risk measure

This chapter contains an empirical analysis of the systemic risk of the 41 largest banks in Europe. Hence, this quantitative analysis is complementary to the qualitative discussion about systemic risk in chapter 2. Also, this chapter discusses how the proposed methodology and results could support the daily work of the regulatory agencies that are subject of chatper 3.

5.1 Introduction

The purpose of this chapter is to present an introduction to the conditional Value-at-Risk (CoVaR) as a tool to measure a single bank's contribution to systemic risk. Chapter 2 analyses systemic risk from a qualitative perspective. This chapter expands the qualitative findings of chapter 2 with a quantitative analysis.

This chapter contains an empirical analysis of the systemic risk contribution of individual banks to the banking system which they are part of. The original data set comprises 41 European banks' share prices from 2002 to 2014. Systemic risk is defined as the possibility that an event on a bank-level could cause a severe instability or even collapse of its surrounding environment. This environment can be a clearly defined banking sector, a wider defined financial system including non-bank financial institutions, and the real economy. The latter can be purely domestic or comprise a selection of countries.

This chapter shows how to apply the ΔCoVaR methodology most prominently suggested by Adrian and Brunnermeier (2011). This measure compares the impact of two different stages of one particular bank on the environment, here the European banking system over a given period. The first step is to look at how the system looks like conditional on the one bank being healthy; the second step is to look how the system looks given that the bank is in distress. The two steps alone deliver the individual CoVaR of the system contingent on the individual bank. This is a simple statistical measure. More interesting is the comparison of the two scenarios in order to derive a difference. This delivers the ΔCoVaR. The Δ now in turn allows for an inference on the marginal systemic risk contribution of the bank. A significant change in the system suggests that the systme follows the bank, i.e. is highly correlated. Put differently there is a co-movement of the bank VaR and the system VaR. Hence, the prefix "Co" stands for co-movement, or also conditional, contagion (Adrian and Brunnermeier, 2011), or contributing VaR (Fullenkamp, 2013).

Obviously, regulatory agencies can incorporate the ΔCoVaR methodology as a macro-prudential tool to identify those financial institutions that pose a threat to the financial stability objective, i.e. are large contributors of systemic risk. This is most likely true for institutions that are systemically important by their sheer size in terms of assets and/or interconnectedness in the financial world.

In addition to the macro-prudential purpose, which is the subject of this chapter, this methodology can also be introduced to banks' own risk management system to counter systematic risk. In order to do so, the conditioning event is reversed, i.e. the own bank's performance is now conditional on the system. The result reveals how exposed the bank is to developments in the banking system. Ideally, a bank's management would employ measures to counter the co-movement and insulate the bank from the industry-specific systematic risk.

Banks are required to employ risk management systems in order to calculate the risk of their investments and produce shock-absorbing capital. The Basel II framework for minimum capital requirements gives guidance. From a macro-prudential point of view on criticism is that Basel II only addresses micro-level risks to calculate regulatory capital. In fact systemic risk concerns are inherent to the financial system in general and banking system in particular. Hence, at the end of this area of research, a macro-prudential tool must be precise enough so that this "calibration can help ensure that each institution pays for the externality it imposes on the system" (Bisias *et al*., 2012, p. 55).

This chapter compares the CoVaR for the financial system, which incorporates a conditioning event, to the unconditional VaR of each individual institution that is an element of the financial system. This chapter accentuates that the sum of all individual banks expressed in VaR does not reflect the riskiness of the system. The latter has an intrinsic macro-level systemic risk component that is not reflected in the existing micro-level risk measures such as the VaR. Thus, the riskiness of the financial system is more than the sum of individual banks' idiosyncratic risk, i.e. their specific risks such as management risk.

This chapter helps understand the nature of systemic risk, using European bank data. Within this PhD thesis this chapter contributes to the previous chapter. Chapter 3 exemplifies the new legal powers to intervene in a bank's business model and certain markets with a range of new tools that are discussed in chapter 4. The new regulatory paradigm of macro-prudence introduces "maintaining financial stability" as a regulatory objective. In order to do so the ΔCoVaR methodology is a simple tool at the regulatory agencies' disposal to detect banks that can become a systemic risk concern in the near future.

The remainder of this chapter is organised as follows: Section 5.2 of this chapter reviews the literature about different systemic risk measures. Section 5.3 gives a general introduction to the most common (non-systemic) tool employed in banks' risk management departments, the Value-at-Risk (VaR). Section 5.4 presents the ΔCoVaR methodology in more detail and section 5.5 discusses the data used in the computation. Section 5.6 discusses the results. Section 5.7 and 5.8 give recommendations for regulators and conclude, respectively.

5.2 Literature Review on systemic risk measures

This section presents an overview of the different approaches to measure the systemic risk of individual banks. The related literature on systemic risk measures in general, and ΔCoVaR in particular, is nascent. However, a number of papers applied the ΔCoVaR to various data sets. There is a growing literature on CoVaR, respectively ΔCoVaR, proposed by Adrian and Brunnermeier (2011). They analyse U.S. data of deposit-taking banks, investment banks, insurance companies, and government-sponsored enterprises, such as "Fannie Mae" and "Freddie Mac" – the two largest mortgage-issuing lenders that played a key role in the U.S. sub-prime crisis 2006. They find a weak link between the institutions VaR and ΔCoVaR. So, the authors conclude that the ΔCoVaR is better suited than the VaR to estimate the systemic risk contribution of the single financial institution. Two banks can have identical VaRs but different ΔCoVaRs. This means that the riskiness of the asset portfolio of one bank has a higher impact on the financial system than the other bank's portfolio risk. Similarly, Adams et al. (2015) find that the design of the VaR measure underestimates spillover effects among financial institutions. Consequently the authors introduce a state-dependent sensitivity VaR that, just like the CoVaR, uses quantile regression and considers the state of the economy (tranquil, normal, and volatile). However, they conduct regressions on the single institution's VaRs and not the returns of assets as Adrian and Brunnermeier, or returns of the single institution's equity as it is done in this chapter. They use data for commercial banks, investment banks, insurance companies, and hedge funds. One finding is that during times of financial distress in the markets, hedge funds become more interconnected. While an increase of one per centage point of such a fund's VaR causes an increase of of 0.05 percentage points in an investment bank's VaR, the same shock to a hedge fund's VaR during a distressed period cause an increase of 0.3 per cent point of the VaR of the insurance industry. This change of correlation of VaRs is revealed considering the state of the economy, by introducing a conditioning variable just like the CoVaR measure does.

Girardi and Ergün (2013) use equity retunrns data of 72 U.S. deposit-taking financial institutions, non depositories, insurance companies, and broker dealers from 2000 to 2008. The authors find that at least for this sample period deposit-taking banks are the systemically most relevant financial institutions. They also find that the ΔCoVaR time-series could have more information to determine the systemic risk contribution of a single institution than the time-series of its VaR, hence "monitoring a firm's tail risk in isolation is not sufficient to determine its systemic risk contribution" (Girardi and Ergün, 2013, p. 22). Gauthier et al. (2012) apply the CoVaR measure to the Canadian banking sectior, but use aggregated interbank exposure data, e.g. bilateral shareholding, interbank deposits, and unsecured loans. Again, considering interbank exposure give a different picture about individual bank risk than analysing bank-specific data.

Wong and Fong (2011) apply the CoVaR methodology to country data rather than micro-level bank data. The authors apply this measure to CDSs of 11 Asian-Pacific countries and find that a country's sovereign risk increased when another economy is in distress; this impact tends to be stronger in crisis times than in economic boom times. Similar to Adrian and Brunnermeier, the authors find that the VaR underestimates the systemic risk, thus the CoVaR methodology is worth further research.

Karimalis and Nomikos (2014) calculate the ΔCoVaR for European banks from 2002 to 2012, which is a slightly narrower data set being used in this chapter. The authors use a copula approach to estimating the average weekly systemic risk contributions of individual banks. This approach respects a change in the correlation of asset returns, depending on the state of the economy. This chapter's findings are in support of Karimalis and Nomikos (2014) in that the French and Spanish banks, on average, generate the highest average systemic risk contributions, but BNP Paribas, Deutsche Bank, BBVA, and Credit Suisse are the most systemically relevant individual banks.

This chapter uses easy-to-compute equity retuns to calculate VaRs and ΔCoVaRs and uses different state variables for these calculations; it derives similar conclusions with less complex data. Also, splitting the whole sample into different periods, i.e. pre-crisis, crisis, and post-crisis period, allows for a ranking of systemic significance among the banks, which is not done in the existing literature. This might help regulatory agencies to allocate supervisory resources to address the most threatening banks to abate the risk of a systemic crisis in its early stage. The literature agrees that leverage and size of the individual banks tend to be good predictors of systemic risk contribution in the form of ΔCoVaR. This chapter, however, focuses on the impact of the state variables such as the short term refinancing conditions rather than bank specific factors. Recall the definitions and differences of the macro-prudential and micro-prudential approach according to Borio (2003). Under a micro-prudential approach a peer group assessment suggest comparing the bank specific factors such as size and leverage. However, the macro-prudential approach also suggests investigating the interconnectedness between banks. Suppose that size and leverage have been addressed by regulatory reform and are not a distinguishing factor among banks in the peer group assessment. The economic conditions in which banks operate are external risk factors to banks under the micro-prudential approach. So, the economic environment, represented by various state variables that are explained in the data section below, gains importance in understanding how systemic relevance of each bank changes over time. In anticipation of the results section, one finding is that refinancing conditions have a different impact on banks and can switch signs through time. Karimalis and Nomikos (2014) point to this but did not further develop the implications for regulation. This finding could suggest that in addition to factors like leverage and size, regulatory agencies should analyse the business model of each bank in more detail, especially when the bank is flagged up as currently being among the most systemically threatening banks.

Benoit *et al*. (2013) compare several systemic risk measures applied by financial regulators. These are marginal expected shortfall (MES), (SRISK), and ΔCoVaR; the definitions follow in the sub-sections below. Using U.S. bank data the authors conclude that different systemic risk measures identify different institutions as systemically important and that the systemic risk ranking of all institutions corresponds with their respective market risk or liabilities.

Bisias *et al*. (2012) present a survey of 28 approaches to measure systemic risk. These different approaches, among the ΔCoVaR, fall into one of five categories with different starting points, which are discussed in more detail in the following sub-sections.

5.2.1 Granular foundations and network measures

First, "granular foundations and network measures" start on a rather abstract view on the financial industry. Borrowing from network analysis, it proposes to create an interbank exposure risk map of the financial world. So this network is visualised with nodes, representing singe financial institutions, and straight lines that connect the nodes to each other. Each node is a legal entity such as an individual bank (see also Gray and Metzing, 2013). This entity itself is a portfolio of contracts which in turn are individual exposures to other nodes. These connections, or exposures, are the financial commitments to other nodes in the form of contractually agreed payment obligations. Put differently, this view aims on the legal interconnectedness of financial institutions to others.

A contract is a legal obligation to another node. However, this network approach defines “obligation” not only as legally binding payment promise but extend the term with contingent claims. These contingent claims also include options. An option gives the holder a right for a specific payment. This means that the holder has a choice to either exercise or decline the option. As long as the option exists it is not a legally binding obligation to the counterparty. Only when the option is exercised it becomes a legally binding obligation of the counterparty. When looking at this over a period of time, this shows that the holders of options undoubtedly have a claim at every point of time. But unless it is not actually exercised, it is not reflected as a certain debt but a contingent debt to the obligator.

Whether options are exercised or not depends on the contingency that leads to that decision. It is obvious that deriving the exact probability for such a contingency, hence payment obligations, is as crucial as it is difficult. Consequently, prudential supervision comprise of modelling and studying the dynamic behaviour of the entirety of institutions and contracts. It is done so by creating a risk map that visualises these legal entities and their connections. In order to give it relevancy and enable a regulatory agency to intervene based on the results the map must be complete. The extensive collecting of data and computing results can come at high costs. For example, regulatory agencies are able to collect more data from banks as the regulated subjects.

5.2.2 Forward-looking risk measurements

The second group of systemic risk measures are “forward-looking risk measurements”. These include tools that are widely known in the financial risk management of banks such as CDS and the VaR. The latter concept is addressed in more detail in the next sub-section. Essentially, historical data of an asset or portfolio of assets is used to derive an estimate for the future risk of that portfolio. The particular challenge is to identify the non-linearity and other higher-order attributes such as the magnitude and changes of correlations within the portfolio. For example, the riskiness of a portfolio expressed in the VaR of the portfolio is not necessarily the weighted sum of the individual VaRs of the assets in that portfolio.

Intuition suggests that the experience with the movement of the portfolio VaR in the past can be used to predict future portfolio VaRs. However, this assumes that the distribution function of the VaR holds indefinitely, these statistical properties are also referred to as being homoscedastic. This is not always the case.

A promising extension is making the prediction of future performance a function of one or more external factors. For example, the portfolio VaR is dependent on factors such as interest rates and movements of other indices and markets. However, assumptions have to be made about the continuation of these relationships – a causality identified today can disappear in the future – and the future values of the external factors as well. Comparing several outcomes of different scenarios rather than relying on one forecast can increase precision. This leads to stress tests that are discussed in the next section.

5.2.3 Stress tests

The third approach to measure systemic risk is to "stress test" financial institutions. In hypothetical forward-looking scenarios the theoretical risk of an institution is analysed. For example, a sudden change in macroeconomic factors like gross domestic product is a simple predictor for the future conditions of banks (Alfaro and Drehmann, 2009). Hirtle *et al*. (2009) give an overview of the 2009 Capital Assessment Program (SCAP), the U.S. Federal Reserve's stress test on U.S. bank holding companies.

Duffie (2011) proposes a more comprehensive scenario analysis that consists of a set of several distinct stress scenarios rather than relying on one big change in one factor. Rather than focussing on the precision of the prediction of a future outcome, using a set of different scenarios allows for gauging the future outcome within a band of possible outcomes.

However, stress testing before the financial crisis of 2008 was not based on clear guidelines with comprehensive principles for conducting a stress test. Stress testing was a trial-and-error process and often lacked expertise by those who designed them and limited by the available data (International Monetary Fund, 2012).

The International Monetary Fund (2012) proposes a list of principles for stress testing on a macro-level. One of the most important principles is identifying those financial institutions that are of systemic importance. Similar to the creation of a risk map proposed in the "granular foundations and network measures" approach, a stress test can only be reliable if the data input reflects the true entirety of the financial system. Otherwise the stress test misses out important data. The ΔCoVaR methodology proposed in this chapter can assist in identifying those institutions that contribute to systemic risk before the actual macro-level stress test is conducted.

5.2.4 Cross-sectional measures

Fourth, "cross-sectional measures" improve the forward-looking measures with the introduction of firm interdependency. The health of the individual institution is conditional on the health of another.

The systemic expected shortfall (SES) (Acharya *et al.*, 2010; Brownlees and Engle, 2015) measures the expected contribution of a financial institution to a systemic crisis. This contribution is derived from the likelihood that a particular institution is undercapitalised conditional on the financial system being undercapitalised. The starting point for the assessment of this tool's potential to predict undercapitalisation of a bank is already existing results: First, the authors use the actuall recommended capital banks had to raise as a consequence of the global financial crisis. The figures for this capital shortfall are derived from the stress test conducted by the U.S. Federal Reserve in 2009. Second, the realised systemic risk is measured in the decline in the value of financial institutions' equity. Third, an increase in credit risk is measured in the spreads of the institutions' CDSs.

After the SES is calculated, the authors take a step back and derive two factors that are the main drives for an institution's SES: the Marginal Expected Shortfall (MES) and leverage. The MES are the extreme losses in the tail of the sector's loss distribution. The tail contains the most extreme values that occur with a low probability. The Systemic RISK measure (SRISK), proposed in Acharya *et al.* (2012) and Brownlees and Engle (2015), is defined as the capital a firm would need in a financial crisis. This SRISK is in fact a stress test tool that depends on a scenario analysis and builds up on marginal expected shortfall (MES). In Acharya *et al*. (2012) the financial system is simulated for a time horizon of six month into the future. Volatilities and correlations are allowed to change over time; no assumptions of homoscedasticity are made. The worst-case scenario is a simulated loss of 40 per cent of a market return index over the six months. The SRISK of an individual bank is a portion of the equity. This portion is the capital shortfall conditional on a crisis.

The Capita shortfall (CS) as taken from Brownlees and Engle (2015) is defined as

$$CS_t^i = kA_t^i - W_t^i = k\left(D_t^i + W_t^i\right) - W_t^i \tag{5.1}$$

The factor k is a fixed “prudential capital fraction” (p. 6), for example 8 per cent minimum capital requirement; $A_{i,t}$ is the value of assets of the firm i in period t; $W_{i,t}$ is the market value of equity; and $D_{i,t}$ is the book value of debt.

Assume that a bank has total assets that are valued at $100.[7] Accordingly the sum of all liabilities, i.e. equity and debt, is $100. Therefore, with k = 8 per cent the minimum capital requirement of the bank is $8. If the bank produces more than this fraction, say 10 per cent equity, i.e. $10, the capital shortfall equals -2. For negative values of CS, the bank has a capital surplus and is perceived to be healthy.

Now assume that a bank has a capital cushion at a level below k. In the numerical example say 5 per cent that translates into $5 when assets are held at $100. The absolute value for the capital requirements of 8 per cent, or $8 in the example, stands against $5 market valued equity. The bank falls short of capital worth $3 which is associated with a state of distress.

So far, the CS is a simple balance sheet ratio. A regulatory agency could identify those financial institutions that have a positive CS and therefore are currently undercapitalised. However, this would be a micro-level regulatory tool. One must not run the risk of relying that the system is stable as long as the vast majority of financial institution report healthy results for the CS. Consequently, the CS now is expanded with a macro-level scope.

To do so, the second step is to anticipate such a shortfall by conditioning the CS on a systemic event C. The result is the systemic risk contribution SRISK. The following is a more precise equation than originally in Acharya *et al.* (2012) but more simple than in Brownlees and Engle (2015):

$$SRISK_t^i = E_t(capital\ Shortfall_{t+h}^i | Crisis_{t+h}) \tag{5.2}$$

The SRISK of institution *i* at time *t* is the expected value at *t* of the CS within the time horizon *t+h*. For example, the time horizon *h* captures the next six months and given that a crisis event occurs within *t+h*.

As previously mentioned a single bank in distress – here expressed as a failure due to capital shortfall – does not necessarily lead to a systemic crisis. Instead, if on an aggregated level the financial sector suffers from a capital shortfall, a systemic crisis is indeed a concern.

[7] In the example calcultions the $ sign is used to indicate a currency, rather than US$ for the sake of readability.

The suffix "+" is introduced and denotes the maximum of $(SRISK_t^i, 0)$, so that

$$SRISK_t^{system} = SUM\left(SRISK_t^i\right) + \tag{5.3}$$

and only those institutions with a positive capital shortfall are considered, i.e. those that actually suffer from distress. Consequently the left hand side of the equation is the key number to determine whether the current state of the financial institutions at time t is likely to absorb imminent distress or whether the losses can lead to a systemic crisis.

Institutions with a negative shortfall have a capital surplus and can be ignored in calculating distress of the financial system. Suppose that a significant number of banks report positive SRISKs. If the sum of their SRISKs is a significant portion of the whole banking sector a distress is less likely to be absorbed by the system, potentially leading to a systemic crisis. If a large amount of institutions is affected, it is not likely that the remaining healthy institutions will take over the struggling banks via mergers and acquisitions or provide emergency loans with their surpluses (Brownlees and Engle, 2015). On an aggregated level excess capital cannot be expected in full to counter SRISK.

However, Idier *et al.* (2013) compare the MES approach to simple measures such as balance sheet ratios already employed by regulators to gauge *ex ante* riskiness of banks. Applied to U.S. bank data from 2007 to 2009, the authors conclude that the commonly used ratios are superior to MES.

Research on systemic risk introduces a conditioning event to the systemic risk formula. The capital shortfall measure essentially suggests a levy on equity to make the institution more robust, hence boosting the stability of the financial system from the micro-level.

The CoVaR is another cross-sectional measure with a conditioning and is developed in more detail below. Suppose that there are only two institutions. The CoVaR is simply the VaR of the one institution conditional on the other institution being on its VaR too. A high value for CoVaR means that if the one institution is in financial distress, the other one accompanies the other. Not necessarily is this a symmetric relationship. Especially banks that are considered systemically relevant due to their sheer size different values of institution-specific CoVaR and ΔCoVaRs occur in comparison to smaller, relatively less significant institutions. A large institution is a source to the stability of the system, hence creates systemic risk; also it is exposed to the risk of the system, i.e. systematic risk. Small institutions are not primary sources of systemic risk individually. However, they individually suffer from developments of the system, i.e. import systematic risk.

5.2.5 Measures of illiquidity and insolvency

Fifth and finally, “measures of illiquidity and insolvency” are crucial because these factors are the essence of crises. Banks convert long-term investments into liquidity via maturity transformation. Therefore a sudden drop in the liquidity is an inherent risk of this intermediation However, balance sheet based measures of the liquidity and solvency are a point-in-time estimate. The risk of liquidity and solvency must be captures over a period of time. Furthermore, the previous approaches stress that some sort of “contingency” must be introduced for the assessments of an individual financial institution’s systemic risk contribution.

Brunnermeier *et al*. (2010) propose a “risk topography”. In contrast to the risk map proposed in the granular data approach above, the authors firstly aim to model how market participants respond to negative shocks rather than relying too much on the current state of their assets and how they would perform under various stress scenarios. Second they investigate whether and how these responses can have feedback effects on an aggregated, system-wide level. Each class of assets (mortgages, loans, etc.) and liabilities (deposits, etc.) are given a liquidity index. These indices are depended on the state of the world. Asset liquidity indices have positive values bigger than 0 and a maximum of 1, liability indexes have negative values smaller than 0 and a minimum of -1. Exceptions are government-backed Treasury bills and overnight lending facilities. Both are state-independent. Treasuries are highly liquid and set to 1; overnight facilities are highly liquid and set to -1. The sum of asset liquidity is compared to the sum of liability liquidity to derive the potential liquidity risk to the single institution.

A simple example of a shock is the scenario of declining asset prices, for example housing prices. The liquidity-related consequence of this scenario is that the institution would have to write off some of their margins on that asset. There is a finite number of values of the shock, say there are N possible values for the housing prices, and a finite number M of levels of write-offs. In summary a $N \times M$ matrix covers the entirety of possible choices an institution can make for that particular risk factor, here the housing price. Each bank reports the four states in which it would face the highest losses. Institutions can face the same shock in the form of declining housing prices but respond with different haircuts on their outstanding mortgages, depending on their internal risk calculations.

Next, for a variety of scenarios all institutions report their estimated losses. Brunnermeier *et al*. (2010) conclude that if banks respond in different ways with their individual choices of each $n \times m$, systemic risk is contained. If, however, responses cluster among a certain combination of shock n and response m, systemic risk materialises. To rephrase, systemic risk is a concern if the financial institutions are homogeneous in their responses to a shock.

Instead of deriving a risk map that contains all financial institutions and their obligations, the risk topography summarises how financial institution will respond to a shock. The key insight of illiquidity approaches is that institutions are not only interconnected with the rest of the financial system through contractual and contingent claims. The dependence on refinancing conditions, such as interbank lending facilities and money markets, are also key factors in systemic risk. Again, the case of Northern Rock and the adverse refinancing conditions it faced despite a sound asset portfolio serves as an example, as captured in chapter 2.

5.2.6 Interim conclusion

Systemic risk builds up in the background of times of financial tranquillity. During such times market participants are prone to under-price risks. Historically low interest rates encouraged financial institutions and households to load on leverage. Yet, opposite to intuition that high leverage can quickly turn to a disaster, risk spreads and volatility experienced historical low values as well (Goodhart, 2008). The financial stability of a bank depends not only on micro-level data such as leverage. The case of Northern Rock demonstrates that the individual bank's health also depends on macro factors, especially changes in the financial system itself. This particular case exemplifies the most severe case that Northern Rock was not led into the crisis by micro-factors, but predominantly by its interconnectedness to the financial system it was part of.

Thus, regulatory agencies must choose a risk measure that takes interdependence into account. Stress-tests look at the bank in various "what if" scenarios and point to the direction of "forward-looking risk measures". The crucial extension of simple risk measures is to introduce a conditioning event. In most of the related academic research papers this event is a sudden drop in the macro-economic environment. Assessing the individual financial institution with the various measures presented above is important to reveal their stability given distress on the macro level.

The crucial difference of the CoVaR and ΔCoVaR in the remainder of this chapter is that the CoVaR measure reverses the research question: Rather than asking "how will the bank be affected if the financial system experiences a shock?" CoVaR asks "how will be the financial system be affected if the bank experiences a shock?"

A drawback of the network measures approach is the costly and perhaps incomplete collection of granular data. The forward-looking measures make contestable assumptions about the relationships of external factors and asset portfolios that undermine predictive power of the simple statistical relationships. The stress test approach analyses financial institutions' health by employing a variety of scenarios. In contrast to the simple statistical forward-looking measures stress tests allow for gauging the health within pre-defined boundaries rather than making a precise prediction. However, stress tests can be criticised for being unrealistic scenarios. A lack of acceptance of these by the regulated industry is exacerbated if the results are the foundation for regulatory intervention in the form of higher minimum capital requirements. Furthermore, regulatory agencies deliberately hold back how they create these stress tests for a good reason. It is important to prevent the industry from adapting to the stress criteria. Unfortunately this counteracts the effort to reduce barriers between the regulatory agencies and the regulated industry. Mutual exchange and understanding how the other party perceives developments in the financial system must be an integral part of macro-prudence.

The ΔCoVaR methodology and its application to European data are explained in section 7.5. Before that the next section gives an introduction to the VaR as the standard tool in financial institutions' risk management. The VaR itself is a forward-looking measure. The introduction of the conditioning event as proposed in the ΔCoVaR is a transition to a cross-sectional approach.

5.3 Introduction to the Value-at-Risk

This section discusses the various methods of the VaR and its limits to capture systemic risk. There are regulations in place, which are based on the Basel capital accord, that require banks to calculate how much regulatory minimum capital to produce in order to counter the threat of losses. The financial institutions that are subject to the Basel minimum capital accord calculate their minimum capital according to the following formula (see BCBS, 2004):

$$Minimum\ capital\ \geq 0.08 \times ["risk - weighted\ assets"\ + 12.5 \times (market\ risk + operational\ risk)] \quad (5.4)$$

To counter the exposure to credit risk as a risk-weighted asset regulated institutions have the choice between creating their own risk models and using external ratings conducted by credit rating agencies. The former requires approval by the institution's supervisor. For the latter, the Basel Committee provides tables to translate the credit agencies' rating notches into weights. For example, claims on central banks with the highest credit rating come with zero risk weight because they are considered safe. Central banks are usually backed by their government; the government can raise taxes to repay claims on its central bank. However, claims on private corporations such as insurance companies with the highest credit ratings come with a 20 per cent weight. Even though they enjoy a top rating, this is not a guaranteed no-default claim.

In case the bank choses the internal ratings-based approach, the VaR is the most popular risk measure in the financial industry. There are several merits to the VaR concepts, however criticism persists. Choudhry (2006) gives an introduction.

The VaR is the maximum loss that can occur on a q-percentile confidence level over a predefined holding period. For example, the bank's risk management estimate a VaR of $100 on the confidence level of q = 5 per cent for the next day. This means that the loss of the portfolio will exceed $100 with the probability of 5 per cent. In other words, the risk management reports that in 95 per cent of the time losses within the next 24 hours will not exceed $100.

There are three distinctive approaches to derive the VaR. The first, and most common method due to its simplicity, is the historical simulation. The correlation method is more advanced and calculates the variances of and co-variances between assets. It is also called parametric method. The third method is the Monte Carlo simulation of the VaR.

The ΔCoVaR methodology in this chapter uses historical stock market data and the parallels to the historical simulation method are obvious. Both methods use historical returns of assets. Before the VaR methodologies are explained in more detail, the next sub-section gives a definition how to derive returns using algebra.

5.3.1 The algebraic concept of returns

This sub-section defines how returns are calculated in this empirical analysis, since different ways to do so have diferent statistical properties. The "return" is a gain or a loss of an investment in a predefined period, see the following equation.

$$r_t = \frac{p_t - p_{t-1}}{p_{t-1}} \tag{5.5}$$

The gain or loss of an investment in t equals the difference of its price p in period t and the previous period $t-1$. This absolute value carries little information how significant this change in value is. Therefore it can be expressed in a percentage. In the simplest form this value is divided by the investments' previous price, hence called "simple return".

However in finance another definition of returns is commonly used: the logarithmic return, or log return. It is the logarithm of ratio of the increase in the price to the previous price.

$$r_{Lt} = ln(\frac{p_t}{p_{t-1}}) \tag{5.6}$$

Equation (5.6) can be rearranged to

$$r_{Lt} = ln(p_t) - ln(p_{t-1}) \tag{5.7}$$

so that the log return of an investment in period t is the difference of the logs of the two prices in t and $t-1$. Using the logarithmic return rather than the simple return can is justified by the practical advantages of the logarithmic return. Hudson and Gregoriou (2010), and references therein, compare the two methods and find that the logarithmic mean of a data series is less than the mean of that series computed with the simple returns method. Yet, this difference does not follow a pattern. Hence the results of one method cannot be compared to the other. The advantage of logarithmic returns increases as data frequency increases. For high-frequency data test results for statistical significance become slim. A slight change in the mean of the data set can be critical whether the null hypothesis is rejected or not. Consequently, a method that regularly computes lower means is more prudent, hence making the results of research statistically more robust.

5.3.2 Historical simulation method

This sub-section focuses on the historical simulation approach to the VaR. Note that a critical assumption is made here that also applies to the CoVaR in later sections: The VaR of a bank is calculated using its stock price returns, representing the value of the bank's equity and not the returns of the portfolio of assets on the balance sheet of the bank, which is usually done. Collecting this kind of data in full was not feasible in course of this PhD. So alternatively it is assumed that the market price of the bank's equity reflects the riskiness of its asset portfolio. Choi and Richardson (2015), and the literature therein, give an overview how equity volatility is affected by asset returns volatility. For the historical simulation, in order to construct the single cash value for the VaR stock returns of a certain time window have to be ordered. For example, a weekly VaR for a given portfolio of investments – financial institutions are in fact a portfolio of investments – is an approximation of the riskiness of that portfolio. In preparation for the ΔCoVaR calculations in this chapter, the stock prices of a bank serve as an illustrative example. A year consists of 252 trading days. The daily closing prices of a bank's shares are the starting point to derive the input data for the VaR of the month, see Figure 5.1, below.

Figure 5.1: Deutsche Bank daily returns in 2014.

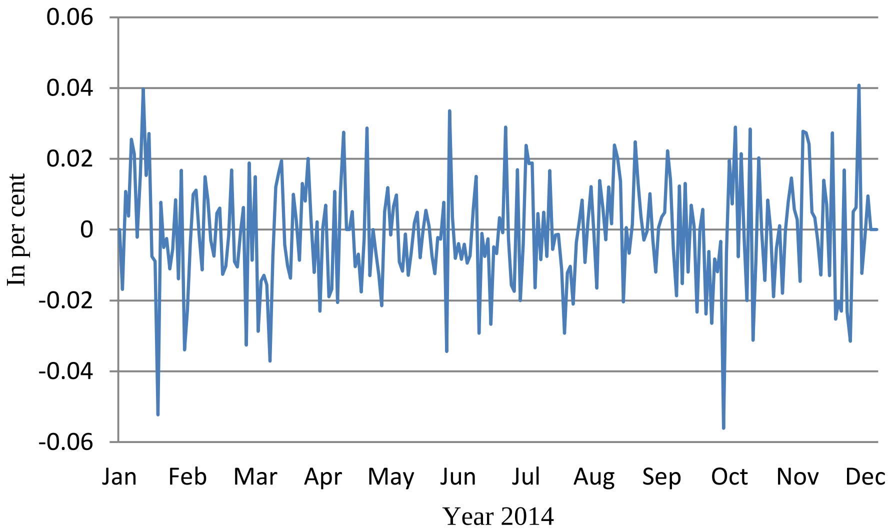


Figure 5.1 shows the daily returns of Deutsche Bank over the 252 trading days in the year 2014. The stock returns are the difference of two closing prices of two successive trading days. Hence, in a second step, all of the now 252 observations are plotted in a histogram in ascending order, from the most negative stock returns to the highest returns, as Figure 5.2 reports.

Figure 5.2: Daily Value-at-Risk of Deutsche Bank in 2014.

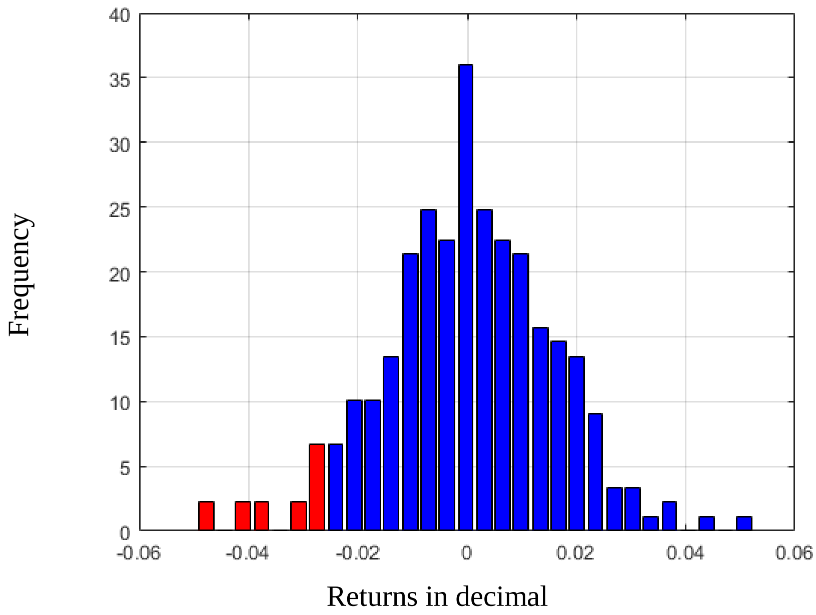


Figure 5.2 reports the daily VaR result of Deutsche Bank for the year 2014. The daily VaR is calculated based on the log-returns of the previous 261 trading days For the sake of simplicity all returns are merged into bins. Also note that losses, i.e. negative returns, are plotted in absolute values to answer the simple question VaR aims to answer: “With a confidence of 95 per cent, what amount of losses is not exceeded?”

The above histogram of VaR in Figure 5.2 already hints to extreme losses that can occur in the left tail. Losses are given in absolute values. The red bins indicate the VaR on a confidence level of 0.95, i.e. with a probability of 95 per cent losses will not exceed 2.6348 per cent. For the sake of simplicity and applicability, these are ignored in the daily risk management. However systemic risk measures look exactly into these extreme loss quantiles.

One advantage of the historical simulation of VaR is that it does not make any assumptions about the distribution of the data. In addition, the concept follows a simple intuition that actually realised returns help gauge the current risk of a portfolio. McKinsey (2012) estimates, that 72 per cent of banks use the historical simulation technique.

One disadvantage of using historical data is the distorted effect of one-off events on the volatility of the VaR. A large one-off movement of the markets can distort the volatility calculations of the VaR. If for example the VaR is calculated over a 30-day horizon a single market shock is captured until the time window moves another 30 days and the event drops out of the data. To circumvent this problem, single observations in the data set can be weighted. A higher weight to the most recent observations would abate the distortive effect of single shocks as the time horizon moves on. The generalised autoregressive conditional heteroscedasticity (GARCH) model does exactly this. However, GARCH models generally "rely on the assumption that future volatilities can be predicted from historic movements" (Choudhry, 2006, p. 34). However, the majority of banks that employ historical simulation for VaR apply equal weights to the time span and only 15 per cent weight (McKinsey, 2012).

5.3.3 Correlation method

This sub-section focuses on the correlation method, or variance-covariance method, to calculate the VaR. It assumes a normal distribution of returns. Furthermore the correlations between the risk factors are assumed to be constant, and so are the deltas of each portfolio constituent. The delta assumption means that the price sensitivity of the portfolio to changes in one risk factor is constant and does not dependent on the current absolute value of the risk factor.

This method was promoted by JP Morgan, a bank. They developed the JP Morgan RiskMetrics, a guide for professionals in the field of finance. This method decomposes the portfolio at hand into its single assets. Assuming that the underlying factors are normal distributed, there is no need to collect and analyse historical data. Conveniently, specialised firms such as JP Morgan provide these statistics for the vast majority of securities in the financial markets.

For illustrative purpose, suppose there is a portfolio with only two securities. The following equation is the way how the variance σ of portfolio ρ is calculated:

$$\sigma_\rho = \sqrt{\alpha_j^2\sigma_j^2 + \alpha_k^2\sigma_k^2 + 2\alpha_j\alpha_k\rho_{jk}\sigma_j\sigma_k} \qquad (5.8)$$

The portfolio variance is the square root of the sum of the various products. The α is the weight within the portfolio of security j and k, respectively. The various σ on the right hand side are the variances of the securities j and k, respectively. The ρ is the correlation coefficient between j and k.

For example (see Choudhry, 2006), a portfolio consists of 60 per cent of security j and 40 per cent of security k, $\alpha_j = 0.6$ and $\alpha_k = 0.4$, respectively. The standard deviations for j and k are calculated and are $\sigma_j = 11.83$ per cent and $\sigma_k = 17.65$ per cent, respectively. The two securities correlate to 64.7 per cent, which means that on average, an increase of 1 in the price of security j is followed by an increase of 0.647 of security k. The portfolio variance according to equation 5.8 is 0.0165. The square root of the variance gives standard deviation of 0.12848.

The choice of the confidence level now determines the portfolio VaR. A 95 per cent confidence level translates into 1.645 standard deviations. Multiplying the confidence level with the portfolio standard deviation gives a portfolio VaR of 0.211. Now multiply this VaR with the current price of the portfolio investment and the portfolio VaR is expressed in monetary terms. If $10 million is invested in this portfolio, the investor will not lose more than $2.11 million in 95 per cent of times.

5.3.4 Monte Carlo simulation method

This sub-section focuses on the Monte Carlo simulation VaR, which is more flexible than the historical simulation and the parametric method. This method uses historical data just like the historical simulation and does not assume a normal distribution of parameters. The historical volatility and correlations of the market factors generate an actual distribution of these factors rather than just assuming a, for example, normal distribution. Based on this historical distribution multiple simulations are conducted "to obtain simulated changes in the market factors over the time horizon to be used in the VaR calculation" (Choudhry, 2006, p. 37). Running the simulations require large computational powers and time.

5.3.5 Final remarks on Value-at-Risk as a risk measure

The VaR has frequently been praised in the past for its intuitive plausibility but criticism was reinforced with the global financial crisis of 2008, both for theoretical reasons and the comprehension of those who employed the VaR. First, in the UK, the Turner Review (2009) reports thats one key concern is the "fundamental question about the validity of VaR as a measure of risk" (p.22). A well-known but underappreciated fact is the endogeneity of the VaR. Current estimates do affect the value of future estimates and destabilise predictions of such. Furthermore, the VaR is not sub-additive which means that the VaR of a portfolio of assets does not equal the sum of the VaRs of each asset. The correlations of asset can quickly change unexpectedly, especially in times of distress (Daníelsson *et al*., 2001; Daníelsson, 2002; Daníelsson and Zigrand, 2006).

Second, the criticism aired by sceptical industry representatives such as Taleb (2008), find that, ironically, it is the very notion of the VaR's conceptual simplicity that leads to overconfidence. In his more general critique on the trend toward automation of routines, Taleb (2012) argues that too much comfort poses less a challenge to the individual and leads to a dangerous comfort. He quotes the example of the Federal Aviation Administration regulations to force "the aviation industry to increase its reliance on automated flying" (p. 43) only to realise that this regulation encourages pilots to often "abdicate too much responsibility to automated systems" (p. 43); parallels to the regulation of what risk measures may be employed and the interpretation of such by the financial industry can be drawn. Even though the CoVaR is worth further research, the general criticism about using historical data should not be forgotten.

The discrepancy between what academics identify as key issues and the financial industry's conduct is obvious. However, this difference existed long enough because of flawed regulations set in the Basel II accord for minimum capital requirements. Besides the criticism of the technical aspects of VaR academics criticise the regulatory framework of Basel II for not appreciating the fact that financial regulation itself is inherently procyclical and the VaR will only exacerbate the problem of endogeneity and undermine the very purpose of financial regulation to "reduce the likelihood of [a] systemic crisis" (Daníelsson *et al*. 2001, p. 3) Financial institutions have the incentive to manipulate their own VaR if this measure is used to determine the regulatory capital they have to produce (Sollis, 2009).

5.4 ΔCoVaR Methodology

This section contains the empirical analysis o the CoVaR. The code used is based on the original open source MATLAB code of Adrian and Brunnermeier (2011), available for download from the Office of Financial Research at: http://www.treasury.gov/ofr.

5.4.1 Definition of CoVaR

Adrian and Brunnermeier (2011) developed a simple statistical tool called ΔCoVaR. It is defined as a measure of "the marginal contribution of institution *i* to overall systemic risk and reflects the difference between the VaR of the financial universe conditional on the stressed and the median state of institution *i*" (p. 17).

In the first step the VaR of institution i must be defined. The VaR of i now serves as the micro-level distress event. Here the VaR is defined as the log-returns on the institution's stocks. Recall from the previous section that the exact monetary VaR is a statement about the maximum potential loss under a given probability. This does not mean that a given VaR marks the exact point where to tell an institution is in financial distress and faces bankruptcy. The CoVaR investigates whether extreme losses of the individual institution and the rest of the financial system correlate. The extreme losses here are the 5 per cent worst return figures. This is exactly what the VaR describes.

However, this section reverses the purpose of the VaR. The risk manager seeks to gauge the worst monetary loss that covers 95 per cent of all the times excluding the few extreme events that only occur in the other 5 per cent of times. For the CoVaR on the other hand these 5 per cent of excessive losses in the tail of the returns distribution are of significance. Hence "financial distress" is somewhat arbitrarily defined as the worst 5 per cent, or the 5 per cent quantile q so that:

$$q = Pr\ (X^i \ \leq \ VaR_q^i), \tag{5.9}$$

where X^i serves as the variable of institution i for which VaR_q^i is defined. It is common practice in risk management departments of banks to define the VaR as the worst 5 per cent of all observations or 1 per cent of all observations, which translates into setting q = 0.05 and q = 0.01, respectively. Howevere, here the 5 per cent level is used to indicate financial distress.

In the second step the conditional event is modelled. The CoVaR is denoted as the VaR of the system j given that a particular institution i is at its VaR previously determined as quantile q, or simply: $CoVaR_q^{j|i}$. Intuitively replacing the conditional event i with equation (5.9) results in:

$$CoVaR_q^{j|X^i = VaR_q^i}. \tag{5.10}$$

Note that j does not necessarily need to be a system or a portfolio of assets, but can also be replaced with another single financial institution, e.g. a bank, hedge fund, monoline insurer etc. This is an interesting alteration in order to supplement a systemically important financial institution's risk management with further information about their exposure to another specific institution.

The third step is to derive the marginal systemic risk contribution of institution i to the VaR of the system j by:

$$\Delta CoVaR_q^{j|i} = CoVaR_q^{j|X^i = VaR_q^i} - CoVaR_q^{j|X^i = Median^i}. \quad (5.11)$$

The $\Delta CoVaR_q^{j|i}$ is the difference between the VaR of the system conditional on institutions i being in distress, for example at the 5 per cent quantile $X^i = VaR_{0.05}^i$ and being in economical normal times, expressed as the 50 per cent quantile $X^i = VaR_{0.5}^i$. For the sake of readability the latter is replaced with $X^i = Median^i$ in the equation above.

Adams *et al.* (2012) further modify the simple ΔCoVaR towards a state-dependent sensitivity Value-at-Risk (SDSVaR). The original ΔCoVaR model does not recognise the state of the economy when deriving spill-over estimates. The SDSVaR introduces three regimes: The most robust state of the economy is a state of tranquillity, in the model expressed with the 75%-quantile. Systemic risk grows especially in this state where market participants are prone to taking risks in the absence of a crisis. This corresponds to the irrational exuberance (Greenspan, 1996) and an immediate undervaluation of actual risk. Secondly, the normal state of the economy is expressed with a 50%-quantile. Finally, a distressed economy is expressed with the 12.5%-quantile.

Regardless of how financial distress is propagated, systemic risk in their definition materialises as a significant and sustained decrease of the impairment of the intermediation capacity of the financial system to supply credit to the real economy. Such a disruption of the financial system can occur directly via contractual links of financial institutions and indirectly via price effects and liquidity spirals, when financial institutions are faced with distressed market conditions. A more detailed qualitative discussion about systemic risk is presented in chapter 2. The next section sums up the key points that are necessary for this chapter on ΔCoVaR.

In the field of finance, the application of quantile regression is a novel technique. Now that systemic risk is a new risk category in its own right, regulatory agencies and banks have to deal with, quantile regression is less a mere nieche in financial research, but grows to be an accompanying tool to (ordinary) least-squares regression.

Choosing a quantile of a data set – previously ranked from lowest to highest – is synonymous to looking into a pre-defined percentile of all observations by splitting the data. Suppose one is interested in the "average" salary of a population to derive a gauge for the living standard in a country. The arithmetic mean is less an informative definition of "average" because salaries are usually skewed and not normal distributed. With few people on the high end of the salary distribution the arithmetic mean suggests too high an average income. The median is a better alternative for determining the average. The median splits the observations in the data set into two portions of equal size, i.e. the 50% quantile. The salary in the middle of all observed salaries is likely to be lower than the mean. Yu *et al*. (2003) give a general introduction and application to different research areas.

For the ΔCoVaR the quantile regression technique is used, which is popular among non-financial economic research, *inter alia* health economics. Koenke and Hallock (2001) give an introduction to quantile regression. They use Abrevaya's (2001) research on the health of new born babies contingent on a set of indicators as a case study how to apply quantile regression. The authors demonstrate that simple linear regression suggests that the older the mother, the lighter the new-born, which is associated with a relatively low level of health. However, quantile regression, which incorporates minimal more effort on the part of the researcher, has its advantages. For example, one result is that when simply using ordinary least squares (OLS) regression, on average women in their thirties – the upper age boundary of the sample – are more likely to give birth to underweight children. However, using quantile regression instead, this "trend" reverses for extreme values, i.e. the top quantile of the age range. Women who are in their late thirties give birth to children with a significant above average weight. With a sample size of 198,377 babies this conclusion is robust at the 1 per cent level.

The CoVaR of the system is the VaR of the system conditional on institution i being on its VaR, more formally:

$$\hat{X}_q^{system,i} = VaR_q^{system} | VaR_q^i. \tag{5.12}$$

Recall the abbreviation from equation (5.9) so that

$$\hat{X}_q^{system,i} = VaR_q^{system} | X^i. \tag{5.13}$$

With the help of quantile regression the CoVaR of a system can also be expressed as

$$\hat{X}_q^{system,i} = \hat{\alpha}_q^i + \hat{\beta}_q^i X^i \tag{5.14}$$

with $\hat{X}_q^{system,i}$ as the predicted value of the system conditional on institution i for quantile q. Recall that X^i in equation (5.9) is the variable for the actual VaR of a particular institution i at the q^{th}-quantile. The quantile regression delivers the estimated beta factor $\hat{\beta}_q^i$. This is a measure of how much i's VaR contributes to the system VaR. The $\hat{\alpha}_q^i$ is the intercept.

In conclusion, the full CoVaR definition with increasing detail from left to right is given by

$$CoVaR_q^{system|X^i=VaR_q^i} := VaR_q^{system}|VaR_q^i = \hat{\alpha}_q^i + \hat{\beta}_q^i VaR_q^i. \quad (5.15)$$

The ultimate aim is to calculate the marginal contribution expressed in ΔCoVaR. The marginal is the difference between the normal state of the conditioning event and distress. For the calculations in this chapter these two scenarios are determined by the 50 per cent quantile and the 5 per cent quantile, respectively; or q = 0.5 and q = 0.05, respectively.

The ΔCoVaR for every institution i is calculated on a weekly basis. In addition to comparing bank returns and system returns a vector of lagged state variables, V_{t-1} serve to indicate the state of the economy. The subscript $t-1$ indicates a one period lag.

The true value of the VaR of the system at time t is

$$X_t^{system} = \alpha^{system|i} + \beta^{system|i} X_t^i + \gamma^{system|i} V_{t-1} + \varepsilon_t^{system|i}, \quad (5.16)$$

with the intercept α, β and γ as the coefficients for the VaR of the single institution and the lagged factors, respectively, and the error term ϵ.

The financial system is defined as the sum of the 41 banks in the sample, see the data section 5.5, below. Consequently the error term can be dropped, so that for the estimation of the VaR of the system it follows that:

$$CoVaR_t^i(q) = \hat{\alpha}^{system|i} + \hat{\beta}^{system|i} VaR_t^i(q) + \hat{\gamma}^{system|i} V_{t-1}. \quad (5.17)$$

Furthermore, note that X_t^{system} and X_t^i from equation (5.16) are expanded with a variable for the quantile in order to derive the final formula for the ΔCoVaR:

$$\Delta \mathrm{CoVaR}_t^i(q) = \mathrm{CoVaR}_t^i(q) - \mathrm{CoVaR}_t^i(0.5) \quad (5.18)$$

$$= \hat{\beta}^{system|i}(VaR_t^i(q) - VaR_t^i(0.5)). \quad (5.19)$$

5.4.2 Properties of ΔCoVaR, its limits, and target audience

This sub-section highlights the statistical properties of ΔCoVaR. The target audience for the ΔCoVaR is foremost a regulatory agency. The aim is to add the ΔCoVaR to the regulatory agencies' toolkit in order to detect systemical banks. Yet, this promising idea could be dampened by the limitations of the ΔCoVaR methodology and available data. The ΔCoVaR measure has the Single Supervisory Mechanism employed by the ECB in mind. However, the data set includes financial institutions from the UK and Switzerland, both not full part of the European "Banking Union". Because of strong linkages of the UK and Swiss financial sector and the rest of Europe, it is plausible to include this data. Furthermore, under the new macro-prudential financial regulation approach and a mutual recognition of foreign financial supervisors and their European peers, so-called "Memorandum of Understanding" (MoU), cross-border co-operation in exchange of data and findings is paramount to capture systemic risk. If she detects that a single financial institution has a high contribution to the CoVaR of the system, regulatory action can lead to a mandatory increase in the countercyclical capital buffer. The regulatory agency can decide to introduce policies with immediate effect on the interconnectedness of the regulated institutions. This might be increasing capital to decrease the threat if counterparty risk materialises, or disentangle the counterparty risk all together by introducing investment restrictions.

This chapter compares individual banks' VaR to their systemic risk contribution measured in ΔCoVaR. Note that despite the general criticism about VaR as a concept for risk management purposes within banks, the VaR here serves a different objective. In this chapter it is not the aim to back-test the VaR concept's qualities for loss prediction. Instead, this piece of research demonstrates the discrepancy between realised losses of one bank and the threat it poses to the whole system; put differently, micro-level losses are screened for their macro-level consequences.

The CoVaR measure suffices six statistical properties, see Adrian and Brunnermeier (2011):

(i) The *cloning* property allows dividing one particular big institution into n smaller clones. The CoVaR of clone n is exactly the same as the CoVaR of the original institution.

(ii) The marginal systemic risk contribution, ΔCoVaR, is not a measure of causality. On the contrary, this is an advantage for it captures causality and common factor exposure at the same time. The focus lays on the quantifiable impact on the co-movement. For example, a common exposure effect can quickly be identified by comparing all institutions' ΔCoVaR at one particular time. If all institutions are affected, there might be a common factor. In isolation one ΔCoVaR observation has limited informational value and should always be interpreted alongside a set of other institutions.

(iii) Because of the quantile regression, CoVaR operates in the tail distribution, where the worst losses occur. The crucial advantage over other statistical measures, such as covariance, is that CoVaR reflects the downward shift of the mean, the increase in variance, and moments such as skewness and kurtosis in the distribution by conditioning on the negative shocks.

(iv) The choice of conditioning the CoVaR allows minimising ambiguity. The conditioning on the q per cent quantile of the losses of an institution i, i.e. the VaR with a q = 0.05, or 5 per cent probability, is a fixed event and therefor independent of i's risk taking. If on the other hand the CoVaR is conditioned on the level of returns, low-risk institutions can have a higher CoVaR. This is because the conditioning event appears to be more extreme to the less risky, i.e. less volatile, institutions.

(v) The CoVaR of an institution i is endogenous and depends on the other institutions' risk-taking. So, generally, CoVaR therefore qualifies to be considered for financial regulation since it allows for internalisation of the negative externalities.

(vi) The CoVaR is also directional. This means that the CoVaR of the system conditional on one institution i does not equal the reversal, i.e. the CoVaR of the institution i conditional on the financial system being in distress.

This insight helps reinforce the macro-prudential regulatory framework. Regulators are provided with empirical results about the notion that the financial system is not the simple aggregate of all individual banks' risk that materialises in their profit-and-loss calculations. The degree of their interconnectedness with the financial network does play an important role, too. This has frequently been labelled the "too big to fail" problem. More precisely, this should be understood as the "too interconnected" problem. Nevertheless, it is true that interconnectedness tends to increase with the absolute size of a financial institution. The bigger the institution is, the more likely it is that it operates in different markets and offers a variety of products and services that are syndetic. Yet, institutions can demonstrate a high degree of interconnectedness and pose a systemic risk if they are relatively small in terms of balance sheet volume, but are key players in niche markets. This is true even more so when big institutions happen to operate in those markets as well. Hence, this constitutes a propagation channel for systemic risk.

5.5 Data

This section contains a discussion about the data used to calculate the ΔCoVaR of banks in section 5.6. Adrian and Brunnermeier (2011) use market-valued total financial assets to derive a ΔCoVaR measure. Alternatively, for systemic risk supervision a broader definition comprise of additional data including off-balance-sheet businesses, derivative exposures and further data that regularly is not captured by accounting techniques. Analyses can also take the opposite direction and have a reduced source of data as a starting point. For example, the ΔCoVaR can be computed for liabilities only. The aim is to identify systemic risk with a ΔCoVaR looking into institutions' reliance on debt funding. Using only equity data on the other hand derives a systemic risk measure based on an asset-liability mismatch. Exploiting the maturity mismatch with an overreliance on short-term funding, over-leveraging, was essential to the 2008 crisis.

This chapter intentionally focuses on a simple ΔCoVaR as an institution's systemic risk gauge. Regulatory agencies are equipped with a tool that screens for those institutions that potentially could pose a threat in the sense of being systemically significant in their contribution to financial instability. Only then regulators can proceed and inquire more detailed into the relevant institutions. Hence for the empirical analysis in this chapter the observed share prices serve as simple institution-specific data, alongside only a few macro-economic key indicators to determine the state of the economy.[8]

[8] The results are computed with Matlab version R2015b. The code is based on various functions. A comprehensive overvies of the ΔCoVaR methodology, coding, and alternative methodologies can be found in Office for Financial Research (2014). Regarding the functions used for this chapter: delta_co_var_v5.m originally by Dimitrios Bisias, Andrew Lo, and Stavros Valavanis, modified by Robert Sollis; rq_fnm.m coded by Koenker, originally proposed by Portnoy and Koenker (1997); bootstats.m written by Robert Sollis.

5.5.1 Financial institution-specific data and the economic system data

This sub-section discusses the choice of bank data used to calculate ΔCoVaR. The bank data used in the empirical analysis is derived from list of constituents of the Euro Stoxx 600 Bank index available in Datastream. It comprises all European exchange listed banks and therefore reflects the regulated financial institutions and the European banking sector. Only regularly traded banks are used. There are banks that are officially exchange listed but the vast majority of shares are in the hands of a few investors. The public is not able to trade the shares.

The data set comprises of financial institutions domestic to Europe, including the UK and Switzerland. However, few exceptions are made in the groups of financial institutions that include deposit-taking commercial banks and investment banks. Especially the latter are global in their business activity. Yet, dropping them from the data set would ignore the close ties between their activities and those of commercial banks and the potential of contagion. This relationship played a major role in the proliferation of the “originate-to-distribute” business model, which was a key contributor to the recent global financial crisis.

The aim of this ΔCoVaR analysis is to support supervisors in gauging systemic risk in the European financial sector. Investment banks with their headquarters outside of the EU, especially U.S. institutions, are out of the regulatory agencies’ reach. However, in order to develop a better understanding of actual systemic risk on a global scale these additional data are necessary, hence they are “too big to be ignored”. Firstly, for the sake of simplicity only European data is used for the ΔCoVaR. Of course, one might argue that this is the first data-related limitation of this contribution at hand. Secondly, the aim of this contribution is not to claim absolute soundness of the results, but to investigate and broaden the understanding how systemic risk behaves.

This contribution echoes Adrain and Brunnermeier (2011) who introduce their ΔCoVaR measure as a purely statistical “without explicit reference to structural economic models” (p. 8). This lack of assumptions does not put the results and therefore the whole analysis at threat. Because of its merely statistical nature it the crucial contribution is that ΔCoVaR identifies the advent and disappearance of possible propagation channels from one financial institution to another. Therefore, ΔCoVaR provides the target audience, i.e. primarily regulatory agencies, with an indicator where to start with further in-depth investigations, for example in the form of regulatory reviews conducted by NCBs in the EU, see chapter 3.

5.5.2 State variables

This sub-section discusses the state variables that determine the state of the economy. It is important to point out that all state variables do not serve as systemic risk factors *per se* according to Adrian and Brunnermeier (2011). Instead they are conditioning variables to assess the current state of the economy in which the financial industry operates.

For the empirical work in this chapter the choice of the kind of state variables that condition the quantile regression closely follows Adrian and Brunnermeier for U.S. banks data and Karimalis and Nomikos (2014) for the European banking sector.

(i) The VSTOXX 50 Volatility Index measures the implied volatility in the European stock market. This is the equivalent to the VIX reported by the Chicago Board Options Exchange as a “fear gauge”. It helps infer market uncertainty. The studies mentioned in the preceding paragraph use the VIX exclusively.

(ii) The change in the Euribor gives away further information about the state of the financial markets. This overnight borrowing condition indicates how easy it is for banks to improve their liquidity situation. The change in Euribor rather than the value shows how that situation can suddenly change for better or worse.

(iii) Change in credit spread, or corporate bond spread of moderately risky private sector investment opportunities and a (quasi) risk-free investment in government bond of equal maturity, here expressed in ten-years Moody’s seasoned BAA-rated corporate bond and the German ten-year government benchmark bond, respectively.

(iv) The S&P 500 Composite Index is a proxy for equity market returns as they deliver returns of the real economy. Because of a close economic integration of the European markets to the globally leading U.S. economy, this index is an appropriate equity benchmark.

Weekly data of these variables were obtained from Datastream. The time horizon for the data collection spans from the beginning of the global financial crisis in Q1 2002 to Q4 2014. The summary statistics for the state variables through the sampled time are shown in the following sections.

5.6 Empirical Results

The ΔCoVaR calculations presented in this section follow the historical simulation method for the VaR. The weekly ΔCoVaRs are calculated using moving window estimations. So, first the daily stock returns of the past 12 months are calculated. Next, the state variables in this particular week serve as conditioning event to estimate the state of the economy to put the co-movement of the stock returns into perspective. Consequently, in order to allow for an analysis of the banks' stock returns with the above weekly state variables, the stock returns are converted into weekly stock returns. For the next week's ΔCoVaR the 12 month observation period for the stock returns moves by one week, i.e. five trading days. The absence of any assumptions of the distribution of returns and especially the tail distribution is a feature rather than a disadvantage (Adrian and Brunnermeier, 2011). The advantage of the ΔCoVaR is that it uses the worst 5 per cent quantile of the return distribution to investigate the co-movement of the financial system contingent on the individual financial institution.

If one considers harnessing ΔCoVaR for estimating future systemic risk contribution restrictions have to be mentioned. Take for example the rolling window of the ΔCoVaR calculation. The more observations are collected, the more precise is the distribution. However, as the introduction section on VaR above explains, the longer this time window is, the longer do shocks prevail in the distributions. The same applies to series of observations that suggest tranquillity, hence potentially underestimating predicted values (Sollis, 2009).

For short periods the implicit assumption that the future will be similar to the recent past is plausible. However, for longer horizons this assumption is not robust.

The following sections report the sample result figures for the respective time period. For the sake of readability the tables are in the results appendix and are referred to in the text. The next sections lead the discussion from the full sample period (2002-2014), to the pre-crisis period (2002-2006), the crisis period (2007-2009), and post-crisis period (2010-2014).

5.6.1 Full sample results (2002-2014)

The following figures report the state variables change in Euribor, corporate bond spread, the VSTOXX, and the S&P 500 equity returns. Table 5.2 in the results appendix summarises the statistics for the four state variables over the full period from 2002 to 2014. This section also presents the results of the linear regression and tests of statistical significance of the state variables on banks' VaR and ΔCoVaR for the full sample period of 2002 to 2014.

Figure 5.3: Change of Euribor, 2002-2014

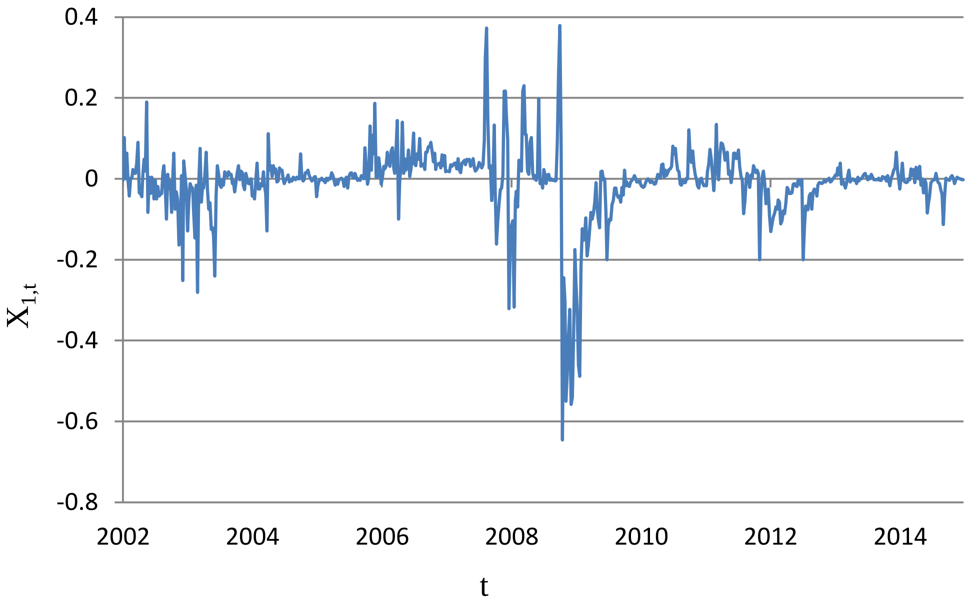
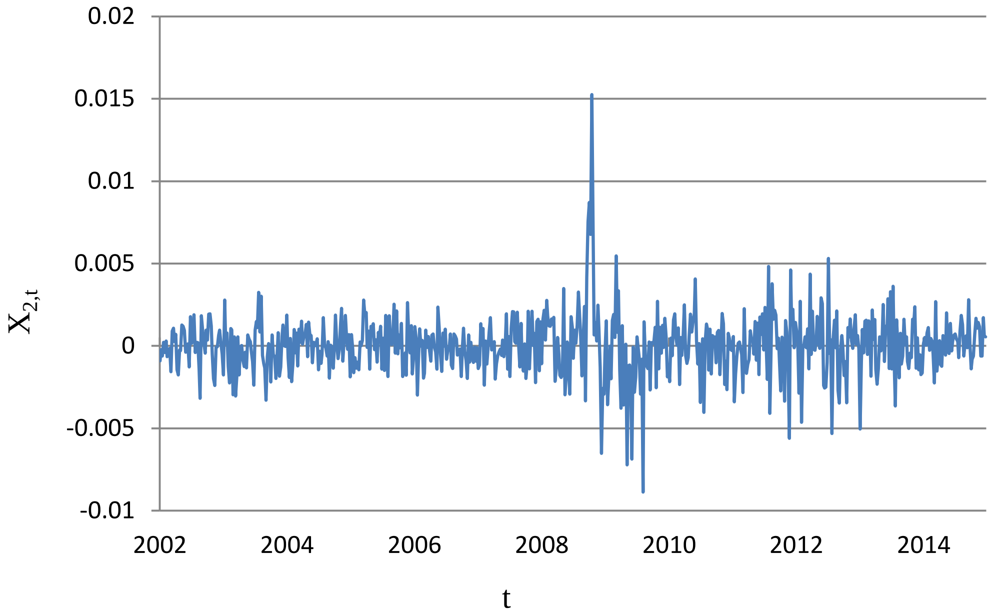


Figure 5.3 shows the full sample change in Euribor as the indicator for the short-term liquidity state variable. In the original recorded values since June 2003 the Euribor maintained constant values slightly above 200 basis points until November 2005. From that point on the rate continuously climbed to approximately 400 basis points in May 2005. The Euribor continued to increase to its peak of 538 basis points, or 5.38 per cent. From there on the rate plummet to around 65 basis points. From late 2012 on the Euribor maintained a value ranging from 20 to 34 basis points.

Figure 5.3 above translates this movement into the change of the Euribor expressed in per cent. It remains constant within the band of 0.2 per cent and -0.2 per cent until the first week of August 2007. One week later the weekly change jumped to 0.37 per cent. From there on the change follows a volatile path. In December of the same year the change experienced a drop of 0.32 per cent. Only four weeks later in the middle of January 2008 the spread decreases to 39 basis points that is reflected in a change of 0.32 per cent. The sharpest reversal was in the weeks of late September to middle of October 2008. A positive change in the Euribor rate of 0.38 per cent was followed by a drop of -0.65 per cent.

Figure 5.4: Corporate bond spread, 2002-2014

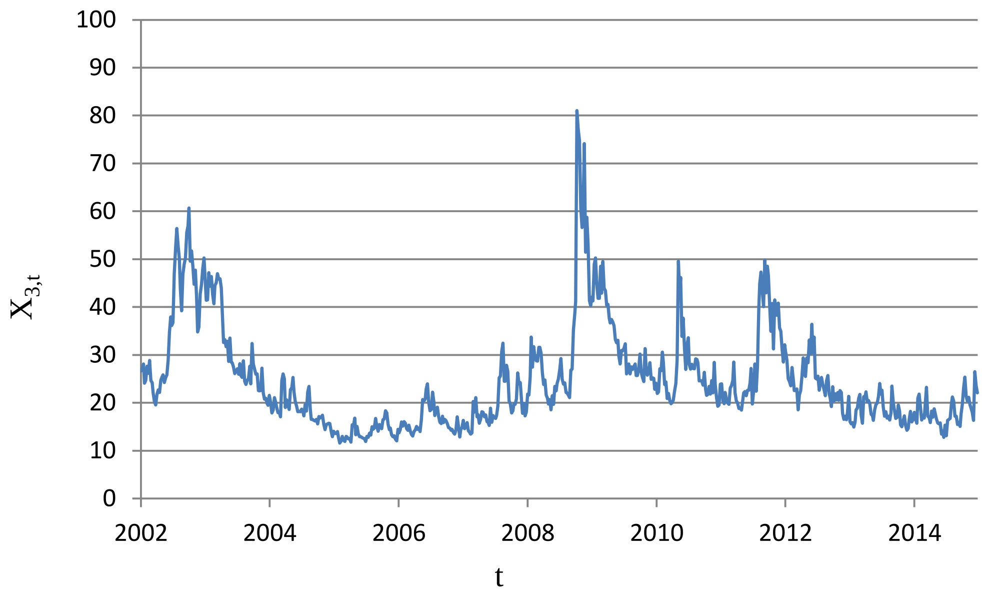


The original Moody's corporate bond reaches a high in late October 2008 with 949 basis points or 9.49 per cent. From 2009 on the interest on the corporate benchmark bond steadily decreases to 475 basis points or 4.75 per cent. The government benchmark bond has a high of 468 basis points in July 2007 and reaches a similar level of 464 basis points in June 2008. But from there on the interest rate steadily decreases to below 100 basis points or 1 per cent in late September 2014.

The corporate bond spread is shown in Figure 5.4. The spread between the two benchmark bonds show a sudden jump to a high of 82 basis points in the middle of October 2008, only days before the peak of corporate bond interest rates. This suggests that the central bank's monetary policy, i.e. making available further lending facilities and revising existing ones, increased funds available to invest. However, relatively safe investments such as government bonds attracted the funds rather than corporations from the real economy. This is crucial information in regards to the financial sector, too. In general terms one would assume that financial institutions have easy access to funds and hence, *ceteris paribus*, have a decreased risk of becoming illiquid. Now this turns out to be not always the case but it depends on the state of the rest of the economy. This is exactly why the CoVaR measure introduces a conditioning event.

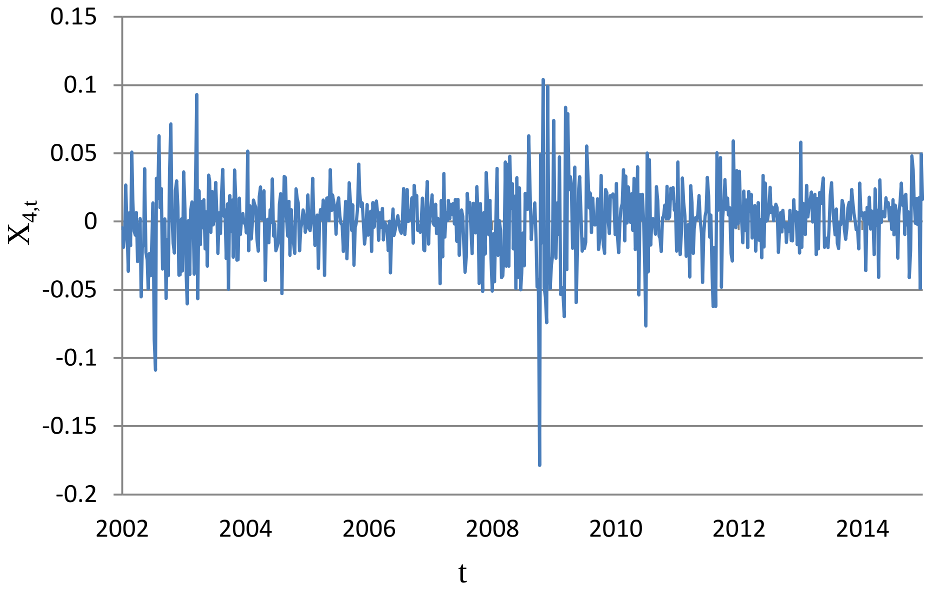
To support this suggestion the mood in the financial markets must be measured. So, the state variable VSTOXX is the European financial market counterpart of the Volatility Index (VIX) in the USA. Figure 5.5 below shows how this “fear gauge” developed from 2003 to early 2015.

Figure 5.5: VSTOXX volatility index, 2002-2014



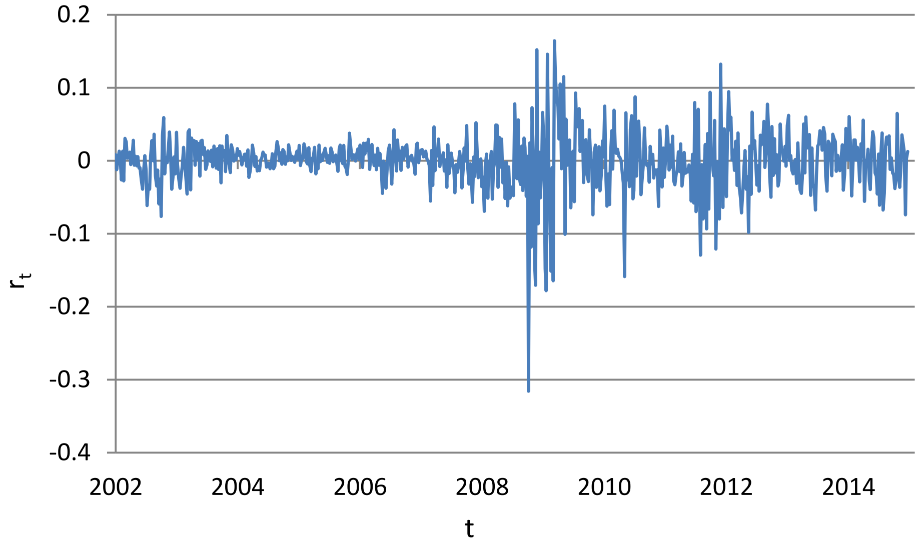
In the years before the financial crisis of 2008 and the U.S. sub-prime crisis of 2006 the financial markets were relatively calm with an implied volatility of below 20 from 2004 to June 2006. A sudden increase occurred in the middle of October 2008 to a peak of 87. The volatility recovered to a level close to 20 in January 2010 and suddenly increased to 50 in May 2010. The peak of the VSTOXX as a measure for financial markets’ unease occurred around the same time as the peak observation of the corporate bond spread.

Figure 5.6: S&P 500 returns, 2002-2014



The returns on the S&P 500 index represent the equity return state variable see Figure 5.6. Unsurprisingly during the crisis period 2007-2009 the returns follow a volatile pattern. The period of tranquillity in 2006 was followed by a gradually increasing volatility. In late 2007 weekly returns touched the bank of 5 per cent and -5 per cent. A minus of 18 per cent in 2008 was followed by a gain of 10 per cent, just to turn negative again and so on.

Figure 5.7: Bank system returns, 2002-2014



A more detailed insight into the bank system returns rather than the whole economy, represented by the S&P 500 index, is presented in Figure 5.7. In late 2008 the European banking sector suffered its largest loss with -32 per cent. Yet two months later a positive return of 16 per cent could be observed. Since the crisis the returns of the banking sector are more volatile than before the crisis. Table 5.3 in the results appendix gives the summary statistics for the bank system returns.

Figure 5.8: Weekly $\Delta CoVaR_t$ for the five largest banks, 2002-2014

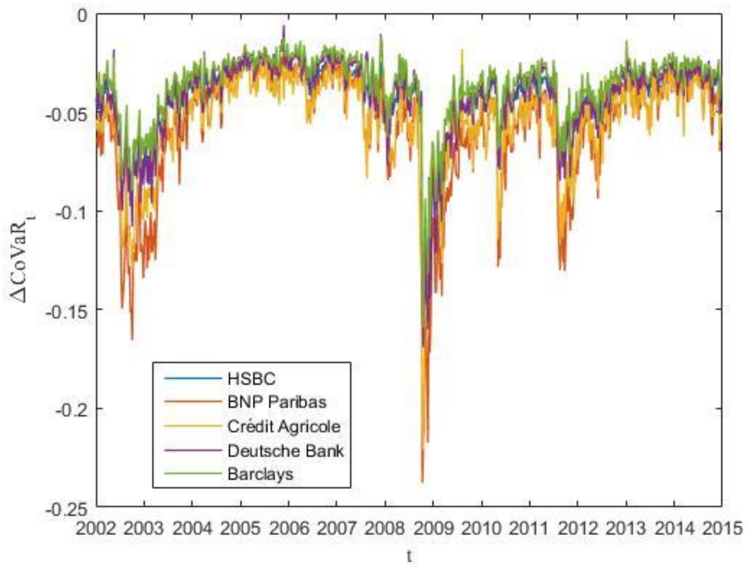


Figure 5.8 above reports the ΔCoVaR results for the five largest banks in the sample. With HSBC and Barclays two British banks are among the largest banks, Crédit Agricole and BNP Paribas represent the two largest French banks, and with Deutsche Bank the largest German bank is represented. The $\Delta CoVaR_t$ gives the change in the financial system' VaR, here the 5 per cent quantile, when the particular bank realises its VaR. The results in the following sub-sections are reported in their decimals.

The weekly systemic risk contributions are similar in their pattern across the full period from 2002 to 2014. Yet, in episodes of spiking systemic risk contributions BNP Paribas has the most severe ΔCoVaR. For example in late 2002 the ΔCoVaR of BNP Paribas was -0.16 (or -16 per cent), followed by Deutsche Bank with -0.13. The lowest ΔCoVaR can be observed in late 2008 with -0.2376 for BNP Paribas, followed by Crédit Agricole (-0.2014), Deutsche Bank (-0.1450), HSBC (-0.1366), and Barclays (-0.1243). So, this means that on average, if these banks are at their respective VaRs – for example BNP Paribas viewed in isolation –, the VaR of the banking system increases by 16 to 23.76 per cent. The results in this chapter are broadly in line with the results reported in the existing literature.

Most contributions derive the average weekly ΔCoVaRs based on a large sample period. However, the results are more informative when the sample is disentangled and separated into the pre-crisis period, crisis period, and post-crisis period in the next sub-sections. Naturally because of tighter data samples the results may vary. For example, the worst estimated weekly ΔCoVaR according to the full sample is BNP Paribas with close to -0.25, or a systemic risk contribution of 25 per cent. However, its crisis-period value is -0.3586.

Note that by design, all banks are systemically important since they are part of the financial system but they differ in the magnitude of their respective importance. So, in the full sample period of 2002 to 2014 the average ΔCoVaR of, for example, BNP Paribas is -0.0578 but for the bottom five banks the estimates are -0.03 or lower. Still, these 5.8 per cent and 3 per cent, respectively, are the average weekly systemic risk contributions – not extreme observations – and do not suggest that there is a threshold that distinguishes between "relevant" and "not relevant" institions. Therefore, it is suggested here that each average and single estimate of weekly ΔCoVaRs should be interpreted considering the estimates of the other 40 banks in the sample.

In addition to the values of each bank's ΔCoVaR, there is a change in ranking of the five largest banks. In late 2008, during the crisis period 2007 to 2009 HSBC, leads the field with an estimated ΔCoVaR of -0.5206, as reported in section 5.6.3, below. This is more than twofold the worst valueover the full sample. Varying the sample period should serve as a word of warning if one considers the application of the ΔCoVaR measure for regulatory purposes. For example, this measure suggests itself to quantify a systemic risk capital buffer according to a polluter-pays principle. Yet, altering the sample period can lead to contrasting results that may not support the capital policy choice by a regulatory agency. So, this is an important limitation of the ΔCoVaR at the current stage of research. Nevertheless, it is worthwile to further investigate how systemic risk contributions of the European banks behave in the different periods in order to derive a systemic risk map, which is reported in section 5.6.4.

In addition the ΔCoVaR is plotted against the VaR to investigate wheter the the measure justifies the effort of introducing a conditioning event into a systemic risk analysis. The simple linear regression, the estimate for the slope, and its respective t-statistic are reported in the results appendix.

Let the linear regression in the scatterplot be:

$$y = \alpha + \beta x + \epsilon \tag{5.20}$$

The dependant variable y is explained by a constant α, the explanatory, or independent, variable x with a slope of β and an error term ϵ, which is normally distributed random variable with a mean of zero and unknown variance.

The slope of the regression of the VaR vs. CoVaR differs dependant on the length of the time series, i.e. full period sample, pre-crisis, crisis, and post-crisis sample period. The t-statistic attached to the slope indicates statistical significance. The H(0) is that the slope of the regression is zero, meaning that the VaR and CoVaR are independent. The value of the t-statistic is calculated with the following equation:

$$t_{score} = \frac{(\hat{\beta} - \beta_0)\sqrt{n-2}}{\sqrt{SSR / \Sigma_{i=1}^{n} (x_i - \bar{x})^2}} \tag{5.21}$$

The $\hat{\beta}$ is the least squares estimator of the slope of the regression. The β_0 denotes a specific value for the estimator that is tested; here this is set to zero since the H(0) is that VaR and CoVaR are independent. The n denotes the degrees of freedom. The SSR stands for sum of squares of residuals, that cannot be explained with the linear regression. Finally, the lower denominator is the sum of squares of the differences between all observed values for the independent variable x and the mean $\bar{x}$ of this variable.

Figure 5.9: Average $\Delta CoVaR_t$ vs. VaR_t, scatterplot and regression line, 2002-2014

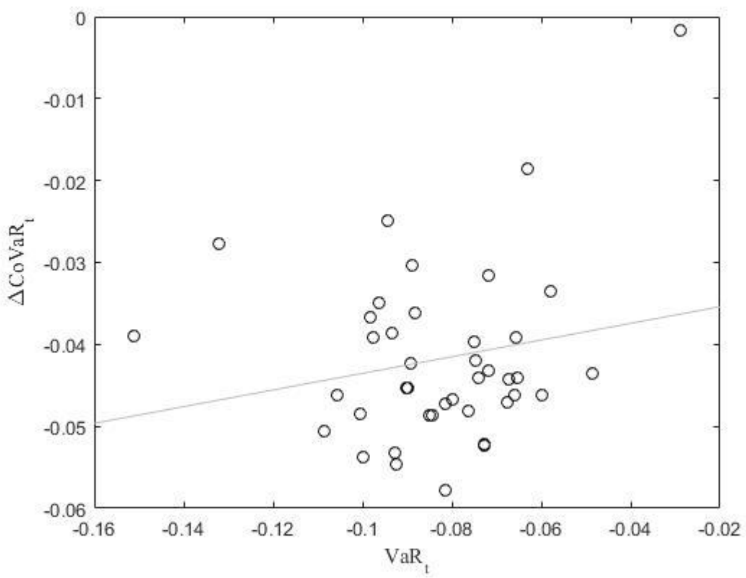


Figure 5.9 plots the linear regression results of the banks average ΔCoVaR over the full sample period and their respective average VaR. Recall that the VaR is a popular measure for estimating the maximum loss over a given period. Here the VaR is based on the stock returns of the banks and serves as a benchmark for the riskiness of the particular bank. In contrast to the ΔCoVaR the VaR has no conditioning event, i.e. the state of the economy is ignored. This figure reports that the two measures are distributed in a cloud that does not give valuable information about the connection of the two measures. Table 5.8 in the results appendix suggest a slope of 0.1017. The t-statistic is 1.3 at the 5 per cent level, which is less than 1.96. So the H(0) that the VaR and CoVaR are independent, is not rejected. Adrian and Brunnermeier (2011) also find a connection between VaR and CoVaR. However, their sample covers data from 1986 to 2010. A strong connection would decrease the advantage of the ΔCoVaR measure – that comes with more computational work – over the simple VaR. Nevertheless, the next sections separate the full sample of this empirical analysisi into the three distinct periods. Doing so gives more information about the relationship between these two variables. For the sake of readability the result tables are kept in the appendix and referred to in the text like below.

[Insert Table 5.5 about here]

Table 5.5 summarises banks' average ΔCoVaR s and state-dependent VaRs on a county level. The median VaR results from the conditioning event that the state of the economy is relatively calm. The distressed VaR results from the conditioning event that the state of the economy is in distress, defined as the 5 per cent quantile.

According to the median VaR the Swedish banking sector is the least concerning with 0.0028. On the other end, Portugal and Greece have a value of -0.0028.

Looking at the VaR in financial distress reveals a different picture. Sweden is the least concerning with -0.0691. Yet, Ireland is the most concerning with an average distressed VaR of -0.151 for the full period of 2002 to 2014.

Interestingly, a ranking according to the average ΔCoVaR leads to different conclusions. The French banking sector bears the most systemic risk of -0.0488 over the full sample period 2002 to 2014 followed by Sweden, who was the safest according to the previous two VaR measures. So, this leads to the conclusion that an isolated analysis of the regular VaR methodology can be misleading. For this reason the following sections address only the average ΔCoVaR for the counties and do not explicitly mention the VaR and distressed VaR. Of course, the countries are not equally represented in the European banking sector. Spain contributes five banks and Germany only two. Yet, this is not an issue. This only supports the view that few banks are systemically more relevant than other banks.

[Insert Table 5.6 about here]

Table 5.6 and Table 5.7, below, report the distressed VaR and ΔCoVaR, respectively. For the distressed VaR the intercept is $\hat{\alpha}$. The following four parameters are the lagged state variables change in Euribor ($\hat{\beta}_1$), corporate bond spread ($\hat{\beta}_2$), VSTOXX volatility index ($\hat{\beta}_3$), and the S&P 500 index as equity return benchmark ($\hat{\beta}_4$).

The respective t-statistics of the estimated parameters can be found on the right-hand side of the tables. Note that these t-statistics are produced with the likelihood ratio version of the bootstrapping method.[9] For example, if the calculated t-statistic value is more negative than -1.96, or more positive than +1.96, we conclude that the estimated parameter is statistically significant at the 5 per cent significance level. This means that it is statistically important.

The respective bank's distressed VaR (Table 5.6) is mainly driven by the VSTOXX. For 35 banks the VSTOXX shows a negative t-statistic. Interestingly four of the Italian banks (Popolare Emilia, Di Milano, Monte Dei Paschi, and Di Sondrio) and one Portugese (Espirito Santo) are not affected by the VSTOXX. This suggests that markets, at least over the full sample period, discriminate among banks. However, the mean of the estimates is -0.0028. On the other hand, the mean of the Euribor is the highest with 5.78, but the Euribor is just significant for 13 banks.

[9] Bootstrapping is a resampling method that assigns a measure of accuracy to the sample estimates. After a parameter has been estimated, bootstrapping allows for measuring the properties of this estimate, for example the estimates mean. The intention is to infer from the estimated mean of the original data set, i.e. sample with the size N, to the whole population. Because a complete set of observations for the population can be obtained or computed, the true mean – and other estimates like the variance – are unknown. However, bootstrapping circumvents this issue and helps gauge the true mean. The original sample is repeatedly resampled so that for each time the mean is computed, the sample looks different. The result is a histogram of bootstrapped means. The researcher now has information about the distribution of the mean of the whole sample. So, if the estimated mean has a low variance, then it is reasonable to assume that the true mean of the population is not unlike the bootstrapped estimate for the mean.

However, the results for the R^2 reveal that with the OLS regression the state variables have a weak explanatory power for the distressed VaR. Note that Table 5.5 ranks the banks according to their average ΔCoVaR but reports the regression results for the distressed VaR. The further down in the ranking the lower are the R^2 tends to be. The most precise regression is the one for the distressed VaR of BNP Paribas with 24.2 per cent. The least precise is for Banca Popolare di Sondrio with a R^2 of 0.0031.

[Insert Table 5.7 about here]

Table 5.7 reports the quantile regression result for the ΔCoVaR over the full sample period 2002 to 2014. Note that the returns on the banking system returns serves as a further state variable. This is the conditioning event discussed in the methodology section. So $\hat{\alpha}$ is the intercept, or constant, and the bank system returns are captured by the parameter estimate $\hat{\beta}_1$. The following four parameters are again the lagged state variables change in Euribor ($\hat{\beta}_2$), corporate bond spread ($\hat{\beta}_3$), VSTOXX volatility index ($\hat{\beta}_4$), and the S&P 500 index as equity returns benchmark ($\hat{\beta}_5$).

In general, the lagged bank system returns are significant for almost every bank in every single sample period, i.e. full, pre-crisis, crisis, and post-crisis period. Moreover, the sign is positive, meaning that an increase in the returns of the system benefits the ΔCoVaR of the single bank, i.e. systemic risk contribution tends to decrease. For example, *ceteris paribus*, an increase of system returns of 1 comes with an increase of the value of ΔCoVaR of 0.69 for BNP Paribas. Note that the sign of the estimate is positive. This means that the ΔCoVaR goes in the same direction as the bank system returns. Since the ΔCoVaR is expressed as a negative number, systemic risk decreases.

For the quantile regression results for the ΔCoVaR in Table 5.7 the change in Euribor has a considerably higher impact on banks' ΔCoVaR compared to the distressed VaR. In the VaR regression the Euribor is statistically significant for only 13 banks. Yet, for the systemic risk calculations it is significant for 30 banks. The t-statistics with a mean of 2.37 are positive and the significance reaches avalue of 5.95 for Mediobanca. The corresponding parameter estimate suggests that an increase in the Euribor of 1 per cent decreases the ΔCoVaR – which is expressed in decimals – of Mediobanca by 12.31. This appears like an extreme value. However, also note that the results are based on weekly changes in the explanatory variables.

Of course an increase of the Euribor of 1 per cent in *one week* is unrealistic. Recall from section 5.5.2 that the variables serve as a conditioning event. So, the purpose of this analysis is to derive the direction and likely magnitude of the effects depending on the state of the financial environment and not to exactly quantify them.

The highest Euribor parameter estimate can be observed for Cantonal Vaudoise with 15.55. However, one exception is HSBC with a negative t-statistic of -2.29 and estimate of -7.25. This difference in direction of the effect could be explained with a bank's reliance on short term funding through the markets. More expensive refinancing conditions put more stress on banks that need the overnight borrowing, while those banks that have excess funds can lend them profitably overnight. Both effects are reflected in the change of the systemic risk contribution.

The second significant parameter is the VSTOXX that gauges the fear in the markets. It is significant for 35 banks for the VaR but all 42 banks for the ΔCoVaR. Now, in contrast to the VaR in Table 5.6, the Italian banks are also affected by the fear gauge when one looks at their systemic risk contribution. For all affected banks, accroding to the t-statistics, the effect is negative for the VaR and ΔCoVaR. The mean indicates the likely magnitude of the variable and is higher in magnitude for the VaR (mean -6.20) than for the ΔCoVaR (mean -5.56).

The results for the R^2 reveal that the OLS regressions are substantially higher than for the distressed VaR regressions. The regression for Bilbao BBVA has a R^2 of 0.574, however Valiant has only 0.1623. On average, the larger the ΔCoVaR is, the larger is the R^2. This is an interesting difference to the previous distressed VaR results, where no such pattern emerges. This suggests that the conditioning event, or "state of the economy" effect, does determine the systemic risk of banks; the ΔCoVaR regression captures this, while the VaR does not.

5.6.2 Pre-crisis results (2002-2006)

This section presents the results of the linear regression and tests of statistical significance of the state variables on banks' VaR and ΔCoVaR for the pre-crisis period of 2002 to 2006.

Figure 5.10: Weekly $\Delta CoVaR_t$ for the five largest banks, 2002-2006

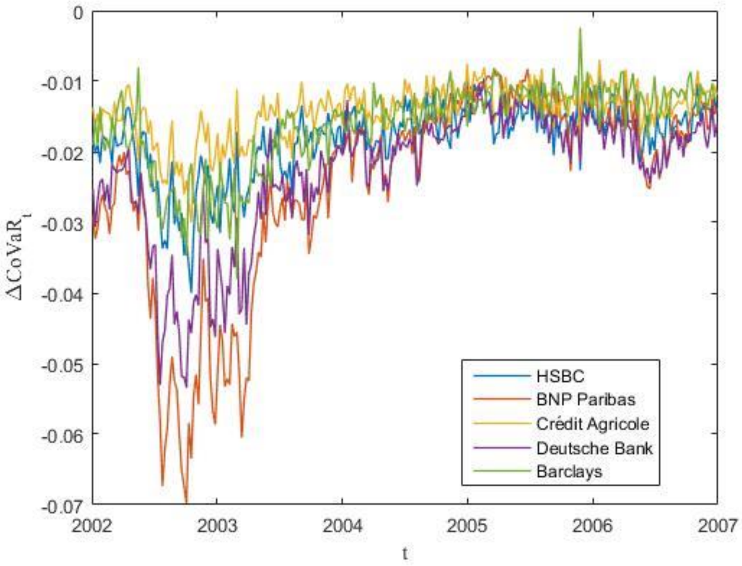


Figure 5.10 above closer investigates the ΔCoVaR results for the five largest banks in the pre-crisis sample 2002 to 2006. With HSBC and Barclays two British banks are among the largest banks, Crédit Agricole and BNP Paribas represent the two largest French banks, and with Deutsche Bank the largest German bank is represented.

BNP Paribas contributes more systemic risk than the others. For example, in late 2002 the bank has the worst weekly ΔCoVaR of -0.0698, followed by Deutsche Bank (-0.0534), Barclays (-0.0324), HSBC (-0.03247), and Crédit Agricole (-0.0240). From that time on the systemic risk contributions come closer to move within the band of roughly -0.01 to -0.02.

Figure 5.11: Average CoVaR$_t$ vs. VaR$_t$, scatterplot and regression line, 2002-2006

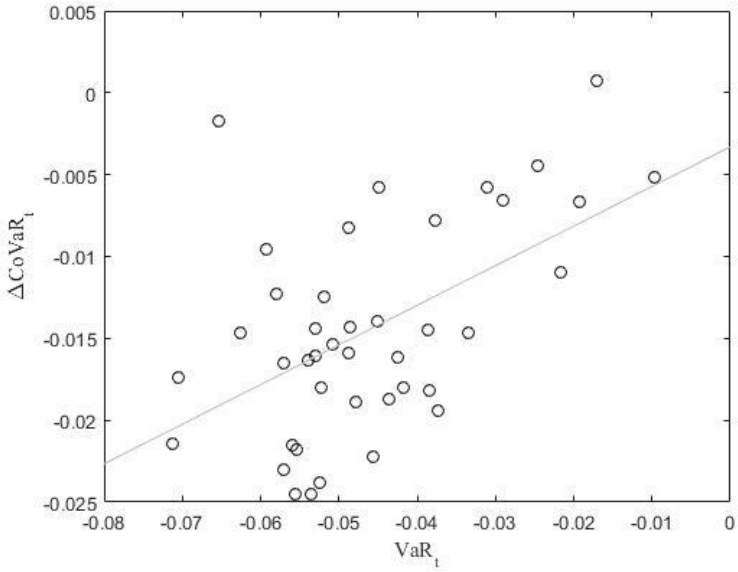


Figure 5.11 shows the scatterplot of the ΔCoVaR against the VaR. This OLS regression is steeper than the full period scatterplot in the previous section. Table 5.13 in the results appendix determines a slope of 0.242 compared to a slope of 0.1017 for the full period regression. However, the value for the t-statistics (3.8968) for the slope expressed in parameter $\hat{\beta}_1$ leads to the rejection of the H(0) that the VaR and ΔCoVaR are independent. So, the resustls suggest that the VaR is significant in explaining the ΔCoVaR at least in this pre-crisis period.

[Insert Table 5.9 about here]

Table 5.9 gives the median VaR, distressed VaR, and ΔCoVaR for the banks in the pre-crisis period 2002 to 2006, ordered from highest to lowest ΔCoVaR. Santander and BNP Paribas jointly lead the field with an average ΔCoVaR of -0.0245; Banco Di Sondrino is the last with an average systemic risk contribution of -0.0007.

[Insert Table 5.10 about here]

Table 5.10 in the results appendix gives the median VaR, distressed VaR, and ΔCoVaR for the countries in the period 2002 to 2006, ordered from highest to lowest ΔCoVaR. Sweden leads the field with an average ΔCoVaR of -0.0207; Finland is the last with an average systemic risk contribution of -0.0058.

[Insert Table 5.11 about here]

Table 5.11 in the results appendix gives the quantile regression for the distressed VaR in the period 2002 to 2006. Again, the VSTOXX is is the most significant variable mean of -4.49 and applies to 34 banks. Again, Italina banks can be found in these exceptions (Mediobanca, Popolare Emilia, and Di Sondrio) together with the Portugese Espirito Santo and two Danish banks, Jyske and Sydbank.

The Euribor, corporate bond spread, and S&P index only apply to four, five, and 11 banks, respectively. The signs are positive for the corporate bond spread and S&P index. As expected, if the equity returns increase, the systemic risk of banks decreases. However, mixed signs can be observed for the Euribor. Karimalis and Nomikos (2014) suggest that the direction of the impact of a variable on the riskiness of a bank can change depending on the state of the economy. The accuracy of the regression ranges from R^2 = 0.24 for Santander to 0.0454 for Banca Popolare di Sondrio.

[Insert Table 5.12 about here]

Table 5.12 in the results appendix gives the quantile regression for the ΔCoVaR in the period 2002 to 2006. The VSTOXX is significant and negative for all 42 banks in the sample with large t-statistics, the mean is -6.20. However, the estimate it low with a mean of -0.0009.

The corporate bond spread increased its importance and is significant for 18 banks' ΔCoVaRs; the spread is significant for only five banks' VaRs. The estimate for most of these banks moves in the band of 2.18 for Deutsche Bank to 4.85 for Valiant. Santander is the only bank with a negative estimate of -2.55. The accuracy of the regression ranges from R^2 = 0.57 for Bilbao BBVA to 0.26 for Banca Populare Di Sondrio and Banque Cantonale Vaudoise.

5.6.3 Crisis results (2007-2009)

This section presents the results of the linear regression and tests of statistical significance of the state variables on banks' ΔCoVaR for the crisis period of 2007 to 2009.

Figure 5.12: Weekly $\Delta CoVaR_t$ for the five largest banks, 2007-2009

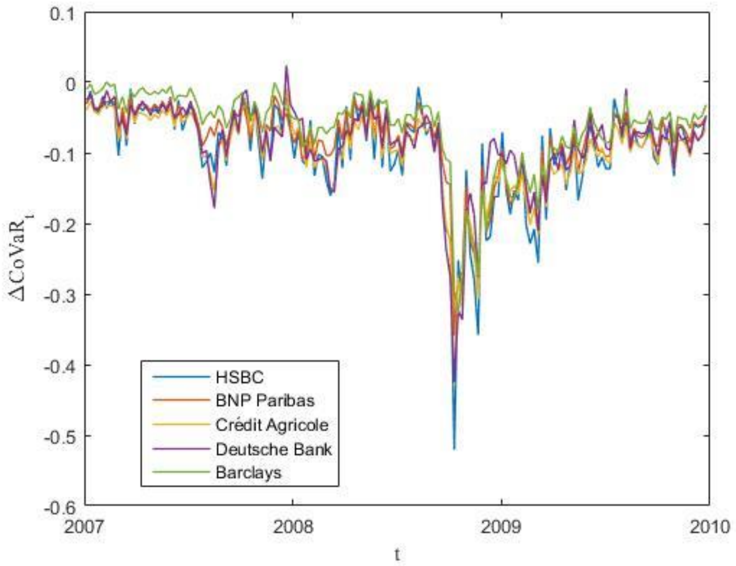


Figure 5.12 reports the weekly ΔCoVaR results for the five largest banks in the sample in the crisis period from 2007 to 2009. Until mid-2007 the ΔCoVaRs followed a relatively calm pattern until they became more volatile. In the autumn of 2008 the ΔCoVaRs became more severe almost instantaneously. The worst recorded ΔCoVaR was for HSBC with a value of -0.5206, followed by Crédit Agricole (-0.4303), Deutsche Bank (-0.4248), BNP Paribas (-0.3586), and Barclays (-2945). It took one year until the systemic risk contributions decreased in volatility and moved back to a band within zero and -0.1 in late 2009.

Also note that the ΔCoVaRs are re-calculated based on the specific time period rather than taking the results from the introductory section 5.6.1. So, the worst value of HSBC's ΔCoVaR is -0.5206 in this sample, but only -0.1366 in the full period sample 2002 to 2014.

Figure 5.13: Average ΔCoVaR$_t$ vs. VaR$_t$, scatterplot and regression line, 2007-2009

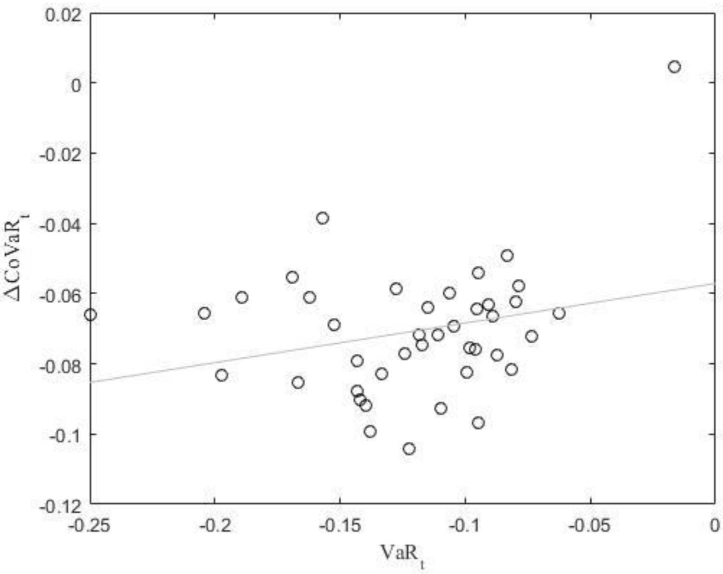


Figure 5.13 plots the ΔCoVaR against the VaR. With a slope of 0.1128 the OLS regression is slightly steeper than the 2002 to 2014 regression of the previous section, see Table 5.18 in the results appendix. With a t-statistic of 1.704 the H(0) that the VaR and ΔCoVaR are independent cannot be rejected at the 5 per cent level, but would be rejected if the analysis would be made less strict at the 10 per cent level. So, there would be no advantage of one measure over the other for the crisis period sample. However, arguably, the crisis period replaced the pre-crisis state of tranquility that led to an underestimation of systemic risk by the VaR measure; put differently the VaR now better indicates systemic risk contributions that the ΔCoVaR already identifies by design. This suggests that the ΔCoVaR plays out its advantage with the featuring of a conditioning event. If so, this measure is more powerful than the VaR to identify the currently most systemically relevant banks and gives regulatory agencies reason to prioritise interventions in these banks.

[Insert Table 5.14 about here]

Table 5.14 reports the median VaR, distressed VaR, and ΔCoVaR for the banks in the crisis period 2007 to 2009, ordered from highest to lowest ΔCoVaR. Intesa Sanpaolo leads the field with an average ΔCoVaR of -0.1043; Valiant is the last with an average systemic risk contribution of 0.0045.

[Insert Table 5.15 about here]

Table 5.15 in the results appendix gives the median VaR, distressed VaR, and ΔCoVaR for the countries in the crisis period 2007 to 2009, ordered from highest to lowest ΔCoVaR. Belgium leads the field with an average ΔCoVaR of -0.0834. Note that Belgium is represented by one bank, KBC, so this bank's ΔCoVaR also represents the country ΔCoVaR. Switzerland is the last with an average systemic risk contribution of -0.0464.

Interestingly, comparing the two tables reveals that there is no clustering of banks according to nationality. For example the five British and eight Italian banks are evenly spread in the ranking. So, again, this bank and country comparison emphasises that regulatory agencies should focus more on banks in particular and put less emphasis on countries. Taking a mere county-level perspective on systemic risk can obfuscate the real sources of systemic risk.

[Insert Table 5.16 about here]

Table 5.16 in the results appendix gives the quantile regression for the distressed VaR in the crisis period 2007 to 2009. The VSTOXX is statistically significant for 39 banks with a mean of -4.80 and negative t-statistics across the board. The three exeptions are again the Italian banks Mediobanca, Di Milano, and the Portugese Commerciale Portugues with no significant values for the t-statistics. The estimates are again small in size with a mean of -0.005.

In contrast to the quantile regressions on the VaR for the full period and pre-crisis period, now the S&P equity returns index is significant with for approximately half of the banks. As expected the S&P returns have positive effects on the VaRs of the banks, the largest being 1.27 for the Belgian KBC. However, negative t-statistics can be observed for the Italian Banco Populare (parameter estimate -0.78) and German Commerzbank (parameter estimate -0.93), suggesting that higer S&P equity returns are counterproductive fot these banks' systemic risk. The accuracy of the regression ranges from R^2 = 0.4 for Jyske and Santander to 0.07 for Mediobanca.

[Insert Table 5.17 about here]

Table 5.17 in the results appendix reports the quantile regression results for the ΔCoVaR in the crisis period 2007 to 2009. The VSTOXX is significant for all banks in the sample with a mean of -5.57. Yet, the estimates for this parameter have a mean of -0.0026.

The S&P equity returns are significant for 20 banks. The t-statistitcs are positive, as expected, but again two execptions can be observed. These are not the same banks as in the previous VaR results. KBC has a t-statistic of -3.30 and Sydbank -2.35. The corresponding estimates are -0.32 and -0.39, respectively. This means that an in crease in the S&P equit returns is counterproductive for the systemic risk contribution of these two banks. The corporate bond spread is significant only for 10 banks, but the sign of significance varies. Swedbank can decrease its systemic risk contribution by 3.51, Populare Emilia's systemic risk becomes more severe by 6.30. The accuracy of the regression ranges from R^2 = 0.69 for Bilbao BBVA to 0.33 for Valiant.

5.6.4 Post-crisis results (2010-2014)

This section presents the results of the linear regression and tests of statistical significance of the state variables on banks' VaR and ΔCoVaR for the post-crisis period of 2010 to 2014.

Figure 5.14: Weekly $\Delta CoVaR_t$ for the five largest banks, 2010-2014

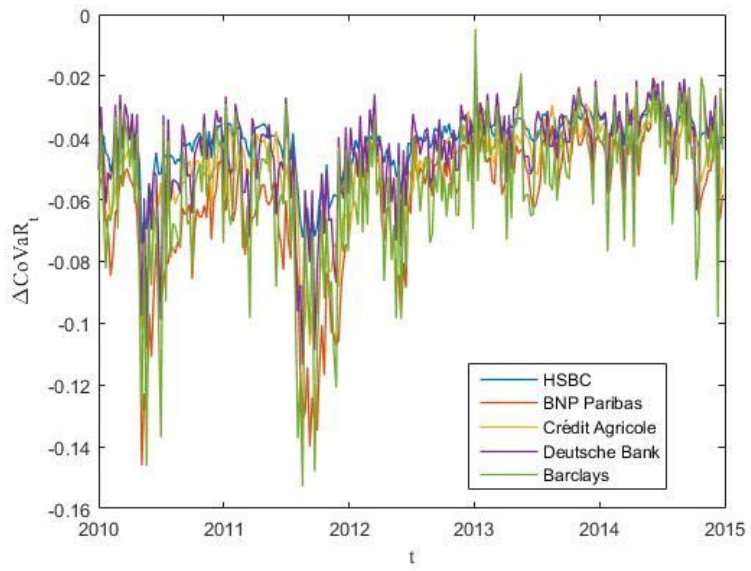
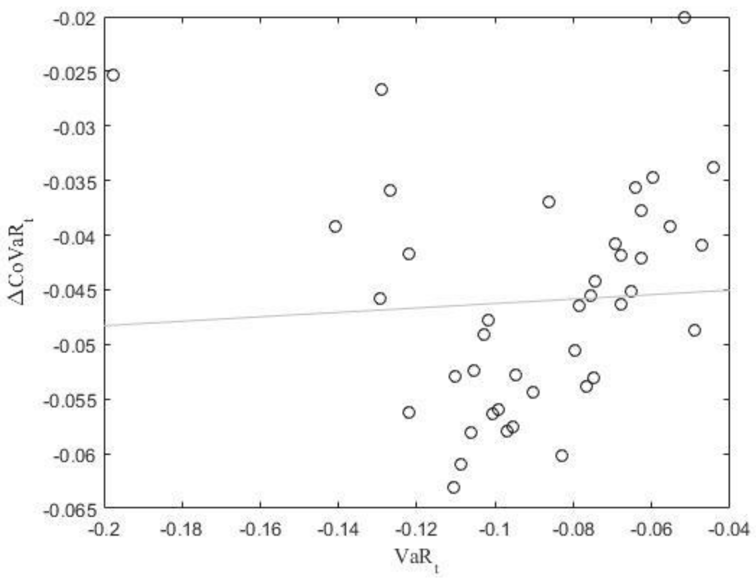


Figure 5.14 reports the weekly ΔCoVaR results for the five largest banks in the sample in the post-crisis period from 2010 to 2014. There are two spikes of a magnitude of approximately -0.14 in mid-2011 and late 2011. However, these are nowhere near the crisis values. Barclays has the most negative ΔCoVaR of -0.1462 and -0.1370. BNP Paribas has values of -0.1302 and -0.0944, respectively. HSBC was the biggest concern during the crisis period. However, at the two peaks after the crisis the bank has the lowest of the five banks' values of -0.0696 and -0.0515, respectively.

Figure 5.15: Average $\Delta CoVaR_t$ vs. VaR_t, scatterplot and regression line, 2010-2014



The above Figure 5.15 plots the ΔCoVaR against the VaR in the post-crisis period 2010 to 2014. Table 5.23 in the results appendix indicate a slope of 0.0203. With a t-statistic of 0.3829 the H(0) cannot be rejected, meaning that the two measures are independent. This continues the suggestion made for the crisis-period: The ΔCoVaR is different from the VaR and an application for macro-prudential regulation should be considered.

However, note that the six matches on the upper left could be statistical outliers. The banks with this discrepancy between ΔCoVaR and distress VaR are National Bank of Greece (-0.0254 vs. -0.1976), Banco Comercial Portugues (-0.0267 vs. -0.129), Monte Dei Paschi (-0.0359 vs. -0.127), Bank of Ireland (-0.0392 vs. -0.1409), Espirito Santo (-0.0417 vs. -0.1219), and Banco Di Milano (-0.0458 vs. -0.1293).

Omitting these banks would result in a regression line that suggests that there is a strong relationship between ΔCoVaR and VaR. As a consequence, this would mean that the ΔCoVaR might not be considerably more informative than the easy to compute distress VaR.

[Insert Table 5.19 about here]

Table 5.19 reports the median VaR, distressed VaR, and ΔCoVaR for the banks in the post-crisis period 2010 to 2014, ordered from highest to lowest ΔCoVaR. RBS leads the field with an average ΔCoVaR of -0.0631; Valiant is the last with an average systemic risk contribution of -0.02.

[Insert Table 5.20 about here]

Table 5.20 in the results appendix reports the median VaR, distressed VaR, and ΔCoVaR for the countries in the post-crisis period 2010 to 2014, ordered from highest to lowest ΔCoVaR. Austria leads the field with an average ΔCoVaR of -0.0576. Greece is at the bottom with an average systemic risk contribution of -0.0254.

Even though the worst crisis period systemic risk concerns are a matter of the past, the average post-crisis ΔCoVaRs do not move back to pre-crisis levels. The banks on the bottom of the table have higher values than the banks on top of the pre-crisis table. For example, Greece's post-crisis ΔCoVaR is higher than Sweden's.

The ranking of the individual banks show the same picture. According to Table 5.19, post-crisis Valiant and National Bank of Greece have the lowest ΔCoVaRs of -0.02 and -0.0254, respectively. The top pre-crisis systemic risk concern was Santander with an average ΔCoVaR of -0.0245, too. For this, compare Table 5.9 again.

[Insert Table 5.21 about here]

Table 5.21 in the results appendix reports the quantile regression for the distress VaR in the post-crisis period 2010 to 2014. With 28 banks the VSTOXX is significant for the least amount of banks compared to the full sample, pre-cisis, and crisis period. The mean for the t-statistics is also lower with -2.90. Like in the other samples, the mean of the estimated values are low with -0.0025.

The S&P equity returns lose explanatory power compared to the crisis period. Only 12 banks' distress VaRs are determined by the equity index. The positive estimates range from 0.41 for Danske Bank to 1.31 for RBS. The single exception is an estimate of approximately -0.81 for Crédit Agricole, so an increase in equity returns increases this bank's systemic risk. The accuracy of the regression ranges from R^2 = 0.18 for Jyske to 0.018 for Espirito Santo. Recall from the section 5.6.2 that Karimalis and Nomikos (2014) suggest a reversal of the signs of the variables' effect on the systemic risk of banks. In addition, within the state of the economy, the results in this analysis here suggest that the direction can differ among banks, too. Anecdotal evidence can be observed for the effect of the corporate bond spread on Deutsche Bank's ΔCoVaRs: In the pre-crisis period the t-statistic is 2.62 but -2.26 in the post-crisis period.

[Insert Table 5.22 about here]

Table 5.22 in the results appendix reports the quantile regression results for the ΔCoVaR in the post-crisis period 2010 to 2014. The t-statistics for the VSTOXX are significant for 22 banks with a negative sign. The mean of the estimate is -0.001. Surprisingly, the S&P eqiuty returns index is significant for almost half of the banks' ΔCoVaR in the crisis period. It is relevant only for four banks here in the post-crisis period. Of these, three have negative estimates, suggesting a further increase in systemic risk. The accuracy of the regression ranges from R^2 = 0.57 for BNP Paribas to 0.10 for Vailant. There is a tendency that high ΔCoVaRs have high values for R^2.

In conclusion, the statistical significance of the variables and the values of the parameters do not tend to correlate with the ΔCoVaR ranking. This is interesting because one would hypothesise that the systemically most relevant banks are exposed to higher scrutiny by markets than the least relevant banks: A change in one of the variables would have a higher impact – i.e. statistical significance and larger estimate – on the most relevant banks. However, this is not so. For example, in the crisis period 2007 to 2009, the lagged corporate bond spread is only significant for 10 banks. But those are evenly spread among the ranking and vary considerable in size. For example, Swedbank ranks 8th most relevant bank and the change in spread has an estimate of 3.51. Natixis is the least systemically relevant bank with a statistical significance of the corporate bond spread in the crisis period. This effect's estimate is -6.97.

Table 5.1: Ranking of banks according to their period-specific average ΔCoVaR

	Rank		
	pre-crisis 2002-2006	crisis 2007-2009	post-crisis 2010-2014
Banco Santander	1	11	12
BNP Paribas	2	10	3
Bilbao BBVA	3	4	16
Deutsche Bank	4	7	25
Svenska	5	28	18
Nordea	6	24	26
Société Générale	7	6	4
Credit Suisse	8	29	11
Danske Bank	9	20	27
Unicredit	10	5	2
UBS	11	15	21
HSBC	12	3	29
DNB	13	35	30
Swedbank	14	8	36
Commerzbank	15	33	7
Lloyds	16	37	14
Barclays	17	26	9
Mediobanca	18	12	5
KBC	19	9	13
Standard Chartered	20	21	33
RBS	21	33	1
Banco Populare Espanol	22	18	19
Intesa Sanpaolo	23	1	10
Banco Populare	24	13	8
Crédit Agricole	25	2	17
Banco Di Milano	26	30	22
Bank of Ireland	27	25	32
Banco Comercial Portugues	28	38	39
Monte Dei Paschi	29	17	35
Banco Espirito Santo	30	31	28
National Bank of Greece	31	22	40
Erste Group Bank	32	23	6
Natixis	33	40	20
Sydbank	34	16	37
Sabadell	35	36	34
Jyske	36	14	24
Pohjola	37	34	31
Valiant	38	41	41
Banco Popolare Emilia	39	19	15
Banque Cantonale Vaudoise	40	39	38
Banca Popolare di Sondrio	41	27	23

Table 5.1 ranks the banks in the sample according to their average ΔCoVaR in each sub-sample, before, during, and after the crisis of 2008. The ranking is derived from Table 5.9, Table 5.14, and Table 5.19 in the results appendix. The biggest systemic risk contributor in the pre-crisis period was Santander with an average ΔCoVaR of -0.0245; in the crisis period Intesa Sanpaolo with an average ΔCoVaR of -0.1043; and in the post-crisis period RBS with an average ΔCoVaR of -0.0631.

There are some interesting results. For example, BNP Paribas, Société Générale, and Unicredit are always in the top 10 of the most relevant banks. In terms of the value of the average ΔCoVaR, Unicredit's systemic risk contribution was -0.0189, -0.0918, and -0.061, in the respective periods.

The Swedish banks Svenska and Nordea experience another extreme systemic risk migration. Before the crisis ranked 5th and 6th, respectively, the banks rank in the bottom half of the table during and after the crisis.

The bottom 16 banks, or roughly 40 per cent of the sample, experience no extreme systemic risk migration according to the ranking. The exceptions are the Austrian Erste Bank Group with a jump to a 6th rank in the post-crisis ranking and Banco Popolare Emilia that was the third last in pre-crisis times, but moved to the midfield. Banco Di Milano ranks 26th, 30th, and 22nd. In terms of the value of the average ΔCoVaR Banco Di Milano's systemic risk contribution is -0.0143, -0.0633, and -0.0458, respectively.

The five largest banks give a mixed picture. Before the crisis, BNP Paribas was in second place and remains in the top 10 with a crisis rank 10 and a post-crisis rank of 3. Deutsche Bank was placed 4th and 7th, but 25th in the post-crisis ranking. Its average ΔCoVaR of -0.0876 during the crisis nearly halved to -0.0442 after the crisis. HSBC experienced an even more severe migration. Starting as 12th before the crisis, the bank became 3rd only to plummet to rank 29th. The average ΔCoVaR decreased by more than 50 per cent from -0.097 to -0.0409. In contrast, Barclays started as 17th, improved to rank 26, but made it to the top 10 after the crisis, ranking 9th. Crédit Agricole has a similar pattern to HSBC. Starting ranked 25th, the bank jumps to 2nd place during the crisis, but drops to rank 17 after the crisis. This is a jump from a comparatively moderate average ΔCoVaR of -0.0144 before the crisis, an increase by a factor of almost 7 to a value of -0.0991, and eventual post-crisis ΔCoVaR of -0.0491, which is still more than threefold the pre-crisis systemic risk contribution. Only Deutsche Bank and HSBC could improve their ranking substantially.

5.7 Recommendations for regulators

Looking further into the extreme losses in the 5 per cent quantile, this measure would suggest itself to quantify a systemic risk capital buffer according to a polluter-pays principle. However, if one considers the application of the ΔCoVaR measure for regulatory purposes, varying the sample period should serve as a word of warning. Altering the sample period can lead to contrasting results that may not support a capital policy choice by a regulatory agency to charge a systemic risk premium on the systemically most relevant banks. So, over the full sample period from 2002 to 2014 there is a considerable change in ranking of the five largest banks in the list of all 41 banks in the sample.

However, this section concludes that the research results should not yet serve to quantify a bank's systemic risk contribution in order to calculate and charge a systemic risk capital buffer. Instead, this should first and foremost serve as an indicator for regulatory agencies to identify those banks that are currently the most systemically concerning. The results can be introduced to the supervisory review NCBs conduct and exchange with the ECB, which is tasked with macro-prudential regulation, as sections 3.4.4.2 and 3.5 demonstrate. Again, the actual estimate for a bank's weekly ΔCoVaR should not be interpreted as a number to calculate capital in addition to a systemic risk capital buffer. Instead, it is argued here that the estimate should be compared to the estimates of all other banks to derive a current systemic risk ranking like table 5.1. So, the regulatory agencies can prioritise the most concerning according to the ranking and allocate their resources accordingly to further investigate the particular banks.

Furthermore, a sudden reversal of the state variables' beta factors suggests that the state variables, such as the change in Euribor, are interpreted differently according to the state of the economy (Karimalis and Nomikos, 2014). So, a change in the sign of the state variables, captured by the beta factors, reflects the change in market perceptions. For example, a generally applicable view on whether a low Euribor reflects calmness cannot be made. The Euribor is the rate at which banks borrow funds from other banks overnight without depositing collateral that could be seized if the funds are not paid back. What on the one hand side makes it easier for banks to meet their short-term financial obligations can be interpreted as stigma during a systemic crisis. The dependence of the bank on external refinancing sources makes it more vulnerable to a drying up of the outside source, hence increasing the markets' perception of the bank's risk. This decline in information is exacerbated by central bank intervention in the form of monetary policy. The post-crisis beta factors for the Euribor differ considerably to the crisis period.

Also the reversal of signs shows an inherent countercyclicality known as “volatility paradox” (Adrian and Brunnermeier, 2009, p.4). Systemic risk is built up long before it materialises, especially during low volatility environments. This reversal has been subject to theoretical and empirical research in, among others, Brunnermeier, 2009; Adrian and Shin, 2010; Brunnermeier and Pedersen, 2009; and Hameed *et al*., 2010. The empirical findings of this chapter are in further support of these arguments.

5.8 Conclusion and implications for promoting financial stability

In contrast to most alternative measures for systemic risk proposed and re-discovered in the aftermath of the 2008 crisis, the ΔCoVaR measure is a purely statistical measure that does not require certain assumptions to validate itself. It therefore follows that, in analogy to any historic VaR calculation, one must handle the results carefully.

The ΔCoVaR shows how systemic risk moves but has no explanatory power as to what factors explain the movement. Thus it is an observation tool complementary to the rest of the regulatory toolkit at the regulator’s disposal to screen for financial institutions that can potentially pose a threat. Only then should regulators take the next step. The lagged values of the VSTOXX and corporate bond spread are significant for the banks’ ΔCoVaR in the pre-crisis and crisis period, but the corporate spreade decreased in importance over the time. So, the spread was significant for 18 (almost all t-statistics are positive), ten (most of the t-statistics are negative), and five (all t-statistics are negative) banks in the respective period. This suggests that markets perceive banks different to other companies, once a crisis occurs. In the light of a recovery of national economies after the crisis of 2008 but ongoing consolidation in the global banking sector, this could be expected.

The results are that systemic risk contribution in the form of ΔCoVaR does not correspond with the micro-level risk measure VaR. Relying on a bank-specific VaR measure neither indicates the magnitude of systemic risk contribution, nor the timing when it materialises. A specific bank’s worst VaR can be higher over the whole observation period than its maximum systemic risk contribution. There are also banks with a reverse relationship.

The results must not be taken as a definite answer to the riskiness of an individual bank. Instead it is the aim of this chapter to develop a measure that serves as a starting point for supervisors for further investigation. Having the new paradigm of macro-prudential regulation in mind and especially if one is contemplating to harness the ΔCoVaR in the process of implementing macro-prudential regulation, limitations have to be discussed. In a more general critique Boucher *et al*. (2013) subject the main systemic risk approaches, including ΔCoVaR, to a model error analysis. They conclude that the results of all of these models are highly sensitive to model errors. Thinking a step further, if financial regulatory agencies ground their opinions about the regulated subjects, such as banks, on these models, arbitrary decisions will be a regularity that would ultimately undermine the credibility of the regulatory agencies.

At the current level of available data serving as input, ΔCoVaR is still is a crude measure. Nevertheless, it is the aim of this chapter to help understand systemic risk and point to possible opportunities to harness the ΔCoVaR method for an application in regulatory agencies. The ΔCoVaR can flag up single institutions that become a systemic concern. With regards to the data input, the data collecting allowances of regulatory agencies must be used to further improve ΔCoVaR, making it more powerful, hence more robust to criticism.

Different kinds of data generally allow for the creation of customised variables that capture the interconnectedness directly. Data of higher quality, frequency, and scope become available due to initiatives on international scales, such as the BIS, see Cerutti *et al*. (2012). So, detailed and full data on proprietary trading (Greenwood *et al*., 2012) are promising, especially now that regulatory agencies are equipped with the statutory powers to do so.

With the lessons learned from the global financial crisis of 2008 a word of warning has to be added that applies to all of the various measures of systemic risk, especially when harnessed by regulatory agencies for their judgements: The results can serve as indication for systemic risk at best and must not be confused with actual proof. Ironically, in the Turner Review (2009), the UK Financial Services Authority – the regulatory agency in charge at that time – find fault with a "misplaced reliance on sophisticated maths" (p.22), while those who are experienced with the matter point out that it should read as "misplaced reliance on sophisticated *statistics* [sic!]" (Sollis, 2009, p. 412).

As mentioned in the introduction, each chapter is set to address the two research questions identified in chapter 2. Therefore, the following discussion aims to answer:

- Does the ΔCoVaR incentivise banks towards sustainable risk-taking?

- Does the ΔCoVaR curb systemic risk when it materialises?

As for the first question, the proposed ΔCoVaR measure supports the regulatory agencies with the detection of those institutions that can be a threat to the financial stability objective. A pro-active agency can put an institution under closer immediate scrutiny. Therefore the ΔCoVaR does not incentivise the regulated institutions directly but is a crucial aid to the regulatory agencies to exercise pressure.

A bank's management still has the freedom to do business as they see fit. Particular investment decisions remain untouched by the presence of the ΔCoVaR own measure and the results. An application of the ΔCoVaR in the bank's risk management system, which is briefly proposed in section 5.4.1, reveals the interconnectedness to the rest of the financial system. Consequently, the bank would use the results to decide whether to undertake precautionary measures to defend against this exposure. For example it can produce more capital to absorb losses linked to this interconnectedness or it can decrease this interconnectedness altogether.

As for the second question, the ΔCoVaR is a detection method and cannot directly contain damages as they occur. Yet, a quantitative judgement about the systemic risk contribution of an institution based exclusively on ΔCoVaR supports the financial stability objective as a crisis prevention tool. Once an institution is identified as a systemic risk concern the regulatory agency can take further action. For example, a further capital premium can be imposed, partly based on the ΔCoVaR results.

For example, suppose that a number of regulated institutions have comparatively highly negative ΔCoVaR values at the same time. Regardless of whether one of these institutions is labelled too-big-to-fail, these institutions can be systemically relevant as a group. Hence this means that a significant portion of the financial system, rather than one institution, turns out to be a systemic threat. The regulatory agency can decide to impose further capital requirements on this group of institutions to dispel concerns in the rest of the financial system.

Of course, reliance in the methodology and the data input must be beyond reasonable doubt and deserves more attention of researchers. Otherwise the regulatory agencies find themselves in a precarious situation. On the one hand, intrusiveness urges regulators and front line supervisors to not omit intervention. On the other hand, overeager agencies could intervene too much too soon, ultimately putting the future credibility of the regulatory framework at risk.

Results appendix A

Table 5.2: Summary statistics for state variables, full period 2002–2014

Variable	Min	Max	Mean	Median	Std	Skewness	Kurtosis
Euribor	-0.0065	0.0038	-0.0001	0	0.0009	-2.3566	17.2408
Corporate spread	-0.0089	0.0153	0	0.0001	0.0018	0.8558	12.8953
Volatility index	11.6	81.03	24.6384	21.955	10.6606	1.7069	6.6446
S&P 500 returns	-0.1788	0.1041	0.0004	0.0016	0.026	-0.5148	7.4068

Table 5.3: Summary statistics for bank system returns, full period 2002–2014

Min	Max	Mean	Median	Std	Skewness	Kurtosis
-0.3158	0.1643	-0.0009	0.0013	0.0398	-1.0884	11.6937

Table 5.4: Median VaR, Distressed VaR, and ΔCoVaR for all banks ordered from largest to smallest ΔCoVaR, full period 2002–2014 (average over time)

Country/Bank	MedianVaR	DistressedVaR	ΔCoVaR
FR BNP Paribas	0.002	-0.0813	-0.0578
IT Unicredit	0.0016	-0.0924	-0.0546
FR Crédit Agricole	0.0014	-0.0997	-0.0538
FR Société Générale	0.0018	-0.0926	-0.0533
ES Bilbao BBVA	0.0019	-0.0729	-0.0523
ES Banco Santander	0.0028	-0.0727	-0.0521
IT BancoPopulare	-0.0011	-0.1085	-0.0506
CH Credit Suisse	0.0004	-0.0845	-0.0486
IT Intesa Sanpaolo	0.0018	-0.0851	-0.0486
DE Commerzbank	-0.0031	-0.1006	-0.0485
CH UBS	0.0005	-0.0763	-0.0481
IT Popolare Emilia	0.0008	-0.0816	-0.0473
SWE Nordea	0.0018	-0.0676	-0.047
SWE Swedbank	0.0024	-0.0798	-0.0467
BE KBC	0.0027	-0.1056	-0.0462
DK Sydbank	0.0032	-0.066	-0.0462
SWE Svenska	0.0042	-0.0599	-0.0461
AT Erste Group Bank	0.0013	-0.0902	-0.0453
ES Banco Populare Espanol	-0.001	-0.0898	-0.0453
DK Danske Bank	0.0021	-0.0674	-0.0443
DK Jyske	0.0021	-0.0653	-0.0441
IT Mediobanca	0.0005	-0.0741	-0.044
GB HSBC	0.0003	-0.0486	-0.0435
GB Standard Chartered	0.0016	-0.0717	-0.0432
IT Di Milano	0.0003	-0.0893	-0.0424
DE Deutsche Bank	-0.0012	-0.0746	-0.042
NOR DNB	-0.0009	-0.075	-0.0397
FIN Pohjola	0.0009	-0.0657	-0.0392
GB RBS	-0.0007	-0.0976	-0.0392
IE Bank of Ireland	-0.0014	-0.151	-0.0389
PT Espirito Santo	-0.0007	-0.0934	-0.0386
GB Barclays	-0.002	-0.0982	-0.0366
GB Lloyds	-0.0001	-0.0883	-0.0361
IT Monte Dei Paschi	-0.0024	-0.0963	-0.0349
IT Di Sondrio	0.0001	-0.0579	-0.0335
ES Sabadell	0.0013	-0.0719	-0.0316
FR Natixis	-0.0009	-0.0888	-0.0304
GR National Greece	-0.0028	-0.1321	-0.0278
PT Comercial Portugues	-0.005	-0.0943	-0.0249
CH Cantonale Vaudoise	0.0008	-0.0632	-0.0186
CH Valiant	0.0011	-0.029	-0.0017

Table 5.5: Median VaR, Distressed VaR, and ΔCoVaR for all countries ordered from largest to smallest ΔCoVaR, full period 2002–2014 (average over time)

Country	MedianVaR	DistressedVaR	ΔCoVaR
France	0.0011	-0.0906	-0.0488
Sweden	0.0028	-0.0691	-0.0466
Belgium	0.0027	-0.1056	-0.0462
Austria	0.0013	-0.0902	-0.0453
Spain	0.0013	-0.0768	-0.0453
Germany	-0.0021	-0.0876	-0.0452
Denmark	0.0025	-0.0662	-0.0449
Italy	0.0002	-0.0857	-0.0445
United Kingdom	-0.0002	-0.0809	-0.0397
Norway	-0.0009	-0.075	-0.0397
Finland	0.0009	-0.0657	-0.0392
Ireland	-0.0014	-0.151	-0.0389
Portugal	-0.0028	-0.0939	-0.0317
Switzerland	0.0007	-0.0633	-0.0292
Greece	-0.0028	-0.1321	-0.0278

Table 5.6: Quantile regression results for the distress VaR model for all banks, full period 2002–2014 (with banks ordered from largest to smallest ΔCoVaR)

	Intercept	Euribor	Corporate bond spread	VSTOXX	S&P returns	t-statistic					
Country/bank	$\hat{\alpha}$	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	$\hat{\beta}_4$	t0	t1	t2	t3	t4	R^2
FR BNP Paribas	0.0135	8.4555	-1.6154	-0.0038	0.0674	1.5603	2.0559	-0.9052	-10.8151	0.5669	0.242
IT Unicredit	-0.005	12.9804	-3.3127	-0.0035	-0.1449	-0.3948	2.3488	-1.3313	-6.8843	-0.8259	0.1722
FR Crédit Agricole	-0.0023	-0.2493	-9.0037	-0.0039	0.0588	-0.1568	-0.0398	-3.1958	-6.7838	0.3035	0.1107
FR Société Générale	0.0105	7.9137	-6.4041	-0.0041	0.0425	0.857	1.5209	-2.7343	-8.9023	0.257	0.1935
ES Bilbao BBVA	-0.0198	3.6459	-4.4492	-0.0021	0.0506	-2.2261	0.783	-2.4578	-5.8137	0.374	0.1577
ES Banco Santander	-0.014	6.8036	-4.8418	-0.0024	0.3767	-1.6335	1.6706	-2.7293	-7.0266	2.9723	0.1985
IT Banco Populare	0.0044	1.0395	-6.989	-0.0046	0.0622	0.2918	0.1503	-2.4878	-7.8153	0.3016	0.09
CH Credit Suisse	0.0169	6.4454	-4.3851	-0.0041	0.0076	2.116	1.5582	-2.7027	-12.3275	0.0605	0.2037
IT Intesa Sanpaolo	-0.0045	4.4463	-5.749	-0.0032	0.1485	-0.4678	0.9023	-2.8606	-8.1604	0.9993	0.1659
DE Commerzbank	-0.0226	0.0796	-2.5376	-0.0032	0.1988	-1.3136	0.0107	-0.7588	-4.7932	0.8217	0.1289
CH UBS	-0.01	8.855	-0.7165	-0.0027	0.6965	-1.004	2.0428	-0.3806	-6.8343	4.854	0.2173
IT Popolare Emilia	-0.0574	4.5955	-5.0931	-0.001	0.0323	-3.5443	0.686	-1.7533	-1.5231	0.1418	0.0316
SWE Nordea	-0.011	16.7751	-3.4738	-0.0022	0.3641	-1.1259	4.0324	-1.8751	-6.204	2.7725	0.1893
SWE Swedbank	0.0181	4.5836	-3.9131	-0.004	0.3439	1.382	0.8581	-1.6506	-8.0094	1.9446	0.1703
BE KBC	0.0531	1.6014	-1.201	-0.0064	0.1218	4.362	0.2685	-0.4929	-12.6069	0.7096	0.2014
DK Sydbank	0.0178	4.9336	-4.1318	-0.0034	0.3029	1.9156	1.2441	-2.2712	-9.0813	2.3358	0.1491
SWE Svenska	-0.0088	10.663	-2.4185	-0.002	0.3872	-1.122	2.7265	-1.5006	-6.181	3.3143	0.144
AT Erste Group Bank	0	15.2863	-1.088	-0.0036	0.1673	0.0021	2.9794	-0.5022	-8.2782	1.0304	0.1458
ES Banco Populare Espanol	-0.05	5.0496	-7.0839	-0.0016	-0.0544	-4.061	0.8477	-2.5147	-3.3418	-0.2775	0.067
DK DanskeBank	0.0099	-0.9219	-4.6967	-0.0031	0.4975	1.1739	-0.2346	-2.6806	-9.2958	4.3346	0.2189
DK Jyske	0.0072	-0.7222	-4.2175	-0.0029	0.4556	0.9042	-0.1862	-2.5416	-9.0967	3.886	0.2273
IT Mediobanca	-0.0432	-0.9807	-0.5149	-0.0013	0.3076	-3.1065	-0.1589	-0.191	-2.2917	1.6207	0.0316
GB HSBC	-0.0151	9.6333	0.1469	-0.0013	0.0769	-2.6091	3.5692	0.121	-5.6704	0.8744	0.1721
GB Standard Chartered	-0.026	14.8984	-7.982	-0.0018	-0.1211	-2.1387	2.8357	-3.5835	-3.6307	-0.7597	0.1372
IT Di Milano	-0.0635	1.2894	-3.9852	-0.001	0.3483	-4.0935	0.1819	-1.3059	-1.6414	1.5481	0.0354
DE Deutsche Bank	-0.0079	16.764	-1.8393	-0.0026	0.0472	-1.0349	4.5738	-1.2164	-8.6623	0.441	0.2101
NORDNB	-0.0032	5.9681	-4.918	-0.0029	0.4189	-0.3888	1.5231	-2.9288	-8.9826	3.4055	0.186
FIN Pohjola	0.0015	-5.6068	-2.9368	-0.0027	0.2674	0.175	-1.3241	-1.7345	-7.8814	2.1219	0.0962
GB RBS	0.0017	9.0931	1.1891	-0.004	0.6214	0.1086	1.3388	0.3801	-7.0422	2.8241	0.1298
IE BankIreland	0.0605	12.0551	-1.9642	-0.0085	0.3537	3.3406	1.4126	-0.5222	-11.1724	1.3246	0.2148
PT Espirito Santo	-0.1043	22.9691	-11.9068	0.0005	0.1609	-7.2622	3.1703	-3.843	0.9051	0.7361	0.0529
GB Barclays	-0.0134	20.1686	-4.21	-0.0034	0.045	-1.2166	3.7029	-1.8247	-7.2486	0.2599	0.1184

GB Lloyds	0.0092	5.4536	-2.369	-0.0039	0.1795	0.6629	0.9797	-0.9369	-7.2769	0.9132	0.1911
IT Monte Dei Paschi	-0.0776	4.5201	-1.2798	-0.0008	0.6532	-4.7586	0.6335	-0.392	-1.1806	2.6911	0.0473
IT Di Sondrio	-0.046	0.5373	-0.3127	-0.0005	-0.0258	-3.4152	0.1019	-0.1295	-0.9535	-0.1442	0.0031
ES Sabadell	-0.0563	10.1184	-6.109	-0.0006	0.0667	-5.5146	2.3309	-3.0437	-1.5022	0.4622	0.0561
FR Natixis	-0.0124	-1.616	0.4692	-0.0031	0.486	-0.9841	-0.265	0.1984	-6.0736	2.7177	0.1419
GR National Greece	-0.0745	0.5092	-8.6664	-0.0023	-0.3126	-2.7606	0.0429	-1.6964	-2.2174	-0.8423	0.0883
PT Comercial Portugues	-0.0441	3.8241	-9.0666	-0.002	0.0756	-2.5511	0.5138	-2.8951	-3.0057	0.3205	0.0837
CH Cantonale Vaudoise	0.0068	-14.6317	-2.2303	-0.0029	0.2898	0.8445	-3.7638	-1.2848	-8.7907	2.4053	0.1689
CH Valiant	-0.0278	-0.0277	-3.9506	-0	-0.0867	-4.4668	-0.0095	-3.0731	-0.1652	-0.9272	0.0368
mean values	-0.0144	5.7853	-3.8965	-0.0028	0.196	-1.0647	1.1613	-1.7129	-6.2014	1.2895	0.1372

Table 5.7: Quantile regression results for the CoVaR model for all banks, full period 2002–2014 (with banks ordered from largest to smallest ΔCoVaR)

	Intercept	Bank system returns	Euribor	Corporate bond spread	VSTOXX	S&P returns	t-statistic						
Country/bank	$\hat{\alpha}$	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	$\hat{\beta}_4$	$\hat{\beta}_5$	t0	t1	t2	t3	t4	t5	R^2
FR BNP Paribas	-0.0059	0.6939	2.351	-2.5653	-0.0011	0.1298	-1.4387	25.3516	1.2289	-3.0748	-6.2489	2.2664	0.546
IT Unicredit	-0.0048	0.5802	6.9429	1.4857	-0.0012	0.1314	-1.0339	20.8381	3.7272	1.5738	-6.5076	2.0737	0.5298
FR Crédit Agricole	0.0014	0.5325	0.7922	-2.8083	-0.0016	0.0089	0.2865	17.5563	0.3381	-2.8499	-8.1418	0.1216	0.5019
FR Société Générale	0.0044	0.5647	1.3824	-0.9401	-0.0016	-0.0031	0.9006	20.8159	0.6586	-1.0135	-8.1591	-0.043	0.5555
ES Bilbao BBVA	-0.0152	0.6997	5.1079	-0.009	-0.0007	0.0917	-3.4699	21.1754	2.3913	-0.0104	-3.6826	1.4016	0.574
ES Banco Santander	-0.0047	0.6901	5.876	-1.3347	-0.0011	0.0398	-0.8762	17.3905	2.6532	-1.3299	-5.1674	0.5284	0.5394
IT Banco Populare	-0.0101	0.4708	1.6557	-1.3635	-0.0011	0.0228	-1.5889	14.3673	0.606	-1.0872	-4.4124	0.2629	0.4673
CH Credit Suisse	0.0061	0.5717	5.4891	-0.4242	-0.0019	0.0655	1.1877	17.2724	2.3155	-0.3863	-9.5519	0.928	0.4657
IT Intesa Sanpaolo	-0.0041	0.5598	8.8376	-0.411	-0.0013	0.1828	-0.7004	14.4613	3.4725	-0.3826	-5.8961	2.1808	0.4802
DE Commerzbank	-0.012	0.4968	6.8097	-2.8939	-0.0011	0.0943	-2.0682	16.6589	2.5567	-2.4815	-4.7376	1.1293	0.4088
CH UBS	-0.0034	0.626	-2.7809	-2.1579	-0.0015	0.0035	-0.5727	14.5029	-0.9707	-1.813	-6.2462	0.0397	0.4488
IT Popolare Emilia	-0.0036	0.5738	7.818	0.4767	-0.0017	0.1141	-0.5388	11.1771	2.6	0.3502	-6.5921	1.2935	0.3594
SWE Nordea	-0.0269	0.6771	8.1967	-1.6081	-0.0005	-0.129	-4.9909	14.9554	3.1788	-1.5044	-2.3478	-1.7751	0.4772
SWE Swedbank	-0.0258	0.5679	4.3287	1.1499	-0.0009	-0.3469	-3.9228	12.9599	1.3308	0.8644	-3.2308	-3.7838	0.4085
BE KBC	-0.0106	0.4272	1.1001	-0.636	-0.001	-0.0269	-2.1409	19.0489	0.4686	-0.6627	-4.9254	-0.3657	0.5218
DK Sydbank	-0.0154	0.6676	8.7263	-2.5276	-0.0013	-0.3738	-2.4856	12.1119	3.0019	-1.9754	-5.398	-4.2834	0.4152
SWE Svenska	-0.0271	0.7196	9.4389	-0.629	-0.0007	-0.2628	-3.9839	11.1185	3.0706	-0.4652	-2.4553	-2.6379	0.4068
AT Erste Group Bank	-0.014	0.4952	5.748	-0.1691	-0.001	0.0559	-2.5301	15.3345	2.2668	-0.1474	-4.7184	0.661	0.4563
ES Banco Populare Espanol	-0.002	0.5095	1.9682	-0.1882	-0.0015	0.2201	-0.3566	12.2326	0.7635	-0.1715	-6.5155	2.7257	0.451

DK Danske Bank	-0.0117	0.6381	7.883	-1.8404	-0.0014	-0.1294	-1.8893	14.1785	2.8354	-1.5367	-5.8026	-1.4835	0.435
DK Jyske	-0.0212	0.6539	9.0342	-0.4202	-0.001	-0.1912	-3.5011	12.2158	3.5217	-0.3414	-4.3768	-2.1481	0.398
IT Mediobanca	-0.0014	0.5897	12.3115	-1.4301	-0.0016	0.078	-0.3096	17.2436	5.9508	-1.5455	-8.8081	1.2308	0.4521
GB HSBC	-0.0074	0.8888	-7.2487	-2.1399	-0.0016	0.1749	-1.1039	13.1722	-2.2882	-1.5425	-5.73	1.7532	0.3847
GB Standard Chartered	-0.001	0.5897	3.1079	-1.9852	-0.002	0.234	-0.1356	10.8345	0.8745	-1.2404	-6.5208	2.153	0.3268
IT Di Milano	-0.0034	0.4736	9.0442	-2.9822	-0.0017	0.2375	-0.534	13.5683	3.1649	-2.5228	-7.18	2.6571	0.4196
DE Deutsche Bank	-0.0086	0.5722	7.5544	0.9338	-0.0011	0.0648	-1.594	16.1161	3.1391	0.8174	-5.1585	0.8348	0.5171
NOR DNB	-0.0147	0.5358	6.2702	-1.5517	-0.0014	-0.0182	-2.4291	12.2027	2.1059	-1.1962	-5.8886	-0.1977	0.4118
FIN Pohjola	-0.0229	0.5888	8.8948	-2.9275	-0.001	0.1624	-3.7445	11.7551	3.2006	-2.5336	-3.8491	1.8981	0.3921
GB RBS	-0.0131	0.4049	13.1387	0.1973	-0.0011	0.0293	-2.3496	15.2498	4.4818	0.154	-5.1358	0.3239	0.422
IE Bank of Ireland	-0.0127	0.26	6.5376	-1.9579	-0.0013	0.1234	-1.7088	9.8247	2.0219	-1.3806	-4.4021	1.1345	0.3389
PT Espirito Santo	-0.0053	0.416	6.902	0.3254	-0.0016	0.0195	-0.848	12.2531	2.3199	0.2472	-6.6562	0.2212	0.3368
GB Barclays	-0.0113	0.3803	10.3162	-2.6108	-0.0012	0.1878	-1.6022	13.6682	3.5643	-1.8131	-4.206	1.9326	0.4205
GB Lloyds	-0.0234	0.4095	3.8658	-2.1856	-0.0008	0.0917	-3.7081	13.2988	1.2489	-1.8452	-3.2176	1.066	0.4224
IT Monte Dei Paschi	-0.0214	0.3715	11.8085	-1.9039	-0.0009	-0.0102	-3.3991	9.4024	3.7249	-1.4808	-3.4868	-0.113	0.3346
IT Di Sondrio	0.0014	0.5775	5.9486	-0.6827	-0.002	0.1912	0.2108	7.8436	1.8716	-0.5164	-7.5533	1.9467	0.3405
ES Sabadell	-0.0082	0.4309	8.9949	-0.8114	-0.0014	0.0211	-1.3491	8.155	3.1119	-0.6224	-5.9974	0.2308	0.3648
FR Natixis	-0.0219	0.3458	5.332	-2.2627	-0.0007	0.0998	-3.5901	9.1849	1.8223	-1.7387	-2.9136	1.0711	0.3761
GR National Greece	0.0068	0.2148	11.2761	-1.215	-0.0024	0.0154	1.0393	7.6	3.7152	-0.9929	-9.3613	0.1702	0.2648
PT Comercial Portugues	-0.0064	0.2787	13.6801	-0.5726	-0.0018	0.1564	-0.9172	6.4425	4.2928	-0.4217	-6.281	1.6345	0.2951
CH CantonaleVaudoise	-0.013	0.2897	15.5514	-0.5426	-0.0019	0.0282	-1.6085	4.0688	3.9052	-0.337	-5.67	0.2357	0.1983
CH Valiant	-0.0137	0.0573	13.0691	-1.2927	-0.0019	0.2326	-1.4385	0.3583	3.0451	-0.6752	-5.0152	1.5857	0.1623
mean values	-0.01	0.5144	6.66	-1.1564	-0.0013	0.0443	-1.6301	13.365	2.3729	-0.9666	-5.5645	0.5088	0.4153

Table 5.8: OLS regression results for regression of the average ΔCoVaR on the VaR for all banks, full period 2002–2014

Parameter	Estimate value	Standard error	t-statistic
$\hat{\alpha}$	-0.0334	0.0067	-4.9897
$\hat{\beta}_1$	0.1017	0.0782	1.3008

Table 5.9: Median VaR, Distressed VaR, and ΔCoVaR for all banks ordered from largest to smallest ΔCoVaR, pre-crisis period 2002–2006 (average over time)

Counrty/Bank	MedianVaR	DistressedVaR	ΔCoVaR
ES Banco Santander	0.0043	-0.0535	-0.0245
FR BNP Paribas	0.004	-0.0556	-0.0245
ES Bilbao BBVA	0.0009	-0.0524	-0.0238
DE Deutsche Bank	0.0028	-0.0571	-0.023
SWE Svenska	0.0013	-0.0456	-0.0222
SWE Nordea	0.0026	-0.0554	-0.0218
FR Société Générale	0.0024	-0.056	-0.0215
CH Credit Suisse	0.0048	-0.0712	-0.0214
DK Danske Bank	0.003	-0.0373	-0.0194
IT Unicredit	0.0027	-0.0478	-0.0189
CH UBS	0.0041	-0.0436	-0.0187
GB HSBC	-0.0002	-0.0384	-0.0182
NOR DNB	0.0014	-0.0523	-0.018
SWE Swedbank	0.0043	-0.0417	-0.018
DE Commerzbank	-0.0006	-0.0705	-0.0174
GB Lloyds	0.0006	-0.057	-0.0165
GB Barclays	0.0011	-0.0539	-0.0163
IT Mediobanca	-0.0006	-0.0424	-0.0162
BE KBC	0.0033	-0.053	-0.0161
GB Standard Chartered	0.0011	-0.0488	-0.0159
GB RBS	0.0011	-0.0508	-0.0154
ES Banco Populare Espanol	0.0024	-0.0335	-0.0147
IT Intesa Sanpaolo	0.0036	-0.0625	-0.0147
IT Banco Populare	0.0015	-0.0387	-0.0145
FR Crédit Agricole	0.0026	-0.053	-0.0144
IT Di Milano	0.0042	-0.0486	-0.0143
IE Bank of Ireland	0.0025	-0.0451	-0.014
PT Comercial Portugues	-0.0024	-0.0519	-0.0125
IT MonteDeiPaschi	0.0035	-0.058	-0.0123
PT Espirito Santo	0.0008	-0.0216	-0.011
GR National Greece	-0.0002	-0.0593	-0.0096
AT Erste Group Bank	0.0049	-0.0487	-0.0082
FR Natixis	-0.0007	-0.0377	-0.0078
DK Sydbank	0.0039	-0.0193	-0.0067
ES Sabadell	0.0028	-0.0291	-0.0066
DK Jyske	0.0029	-0.0311	-0.0058
FIN Pohjola	0.0028	-0.0449	-0.0058
CH Valiant	0.0013	-0.0097	-0.0052
IT Popolare Emilia	0.0018	-0.0246	-0.0045
CH Cantonale Vaudoise	0.0007	-0.0654	-0.0017
IT Di Sondrio	0.0015	-0.017	0.0007

Table 5.10: Median VaR, Distressed VaR, and ΔCoVaR for all countries ordered from largest to smallest ΔCoVaR, pre-crisis period 2002–2006 (average over time)

Country	MedianVaR	DistressedVaR	ΔCoVaR
Sweden	0.0027	-0.0476	-0.0207
Germany	0.0011	-0.0638	-0.0202
Norway	0.0014	-0.0523	-0.018
Spain	0.0026	-0.0421	-0.0174
France	0.0021	-0.0506	-0.017
United Kingdom	0.0007	-0.0498	-0.0164
Belgium	0.0033	-0.053	-0.0161
Ireland	0.0025	-0.0451	-0.014
Switzerland	0.0027	-0.0475	-0.0118
Italy	0.0023	-0.0425	-0.0118
Portugal	-0.0008	-0.0367	-0.0118
Denmark	0.0033	-0.0292	-0.0106
Greece	-0.0002	-0.0593	-0.0096
Austria	0.0049	-0.0487	-0.0082
Finland	0.0028	-0.0449	-0.0058

Table 5.11: Quantile regression results for the distress VaR model for all banks, pre-crisis period 2002–2006 (with banks ordered from largest to smallest ΔCoVaR)

	Intercept	Euribor	Corporate bond spread	VSTOXX	S&P returns	t-statistic					
Country/bank	$\hat{\alpha}$	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	$\hat{\beta}_4$	t0	t1	t2	t3	t4	R^2
ES Banco Santander	0.0011	8.2294	3.6384	-0.0023	0.2199	0.1391	1.2893	1.3499	-7.7993	1.5817	0.2456
FR BNP Paribas	0.0146	-3.5771	0.7898	-0.003	-0.2443	2.1991	-0.624	0.3244	-10.9012	-1.8679	0.2746
ES Bilbao BBVA	-0.0007	-7.0109	5.955	-0.0022	0.0686	-0.0986	-1.0955	2.2837	-7.4606	0.5533	0.2251
DE Deutsche Bank	-0.0013	-5.5439	-3.4696	-0.0024	0.0888	-0.1621	-0.9028	-1.2526	-7.3277	0.6001	0.246
SWE Svenska	-0.0206	-1.1345	0.7459	-0.0011	0.3549	-2.29	-0.149	0.2297	-2.7385	2.0769	0.0944
SWE Nordea	-0.0078	9.9527	5.2941	-0.002	0.6125	-0.9088	1.4566	1.8415	-6.0002	4.0361	0.2213
FR Société Générale	0.0081	-7.2345	-2.8002	-0.0027	0.0091	1.1477	-1.2105	-1.1788	-9.6035	0.0735	0.2721
CH Credit Suisse	0.0051	-7.9752	-2.0078	-0.0033	-0.1501	0.3804	-0.7671	-0.4869	-6.0684	-0.632	0.1737
DK Danske Bank	-0.0039	-5.089	0.0438	-0.0014	0.16	-0.5161	-0.8298	0.0173	-4.5733	1.2484	0.1152
IT Unicredit	0.0127	12.2702	-3.1987	-0.0026	-0.2179	1.7058	1.9811	-1.2586	-8.4473	-1.5941	0.2159
CH UBS	-0.0032	-13.1216	2.8889	-0.0017	0.1793	-0.4214	-2.1329	1.1156	-5.5273	1.4398	0.203
GB HSBC	-0.0153	-2.7768	-3.4616	-0.001	-0.0667	-2.1819	-0.5011	-1.6003	-3.6232	-0.6003	0.1119
NOR DNB	-0.0184	7.968	-4.3008	-0.0015	0.3426	-2.3169	1.1339	-1.5346	-4.7225	2.4079	0.1393
SWE Swedbank	-0.0177	-4.6478	1.9662	-0.001	0.2826	-2.8133	-0.9556	0.9431	-3.7963	2.5377	0.1605
DE Commerzbank	-0.0015	-22.6226	1.9553	-0.0029	0.4493	-0.114	-2.1571	0.4256	-5.6242	1.9344	0.2497
GB Lloyds	-0.0145	14.7049	2.704	-0.0018	-0.0998	-1.6025	2.0335	0.8697	-5.1547	-0.6442	0.2551
GB Barclays	-0.0183	13.1676	3.4693	-0.0015	-0.0178	-2.2291	1.8195	1.1716	-4.4317	-0.1164	0.1609
IT Mediobanca	-0.0275	9.0563	3.6273	-0.0006	0.1452	-3.2481	1.3752	1.391	-1.8888	1.0954	0.0861
BE KBC	-0.0118	-2.0195	6.7445	-0.0017	0.1969	-1.24	-0.2583	2.0666	-4.7639	1.0979	0.1067
GB Standard Chartered	-0.02	-3.1704	2.6485	-0.0012	-0.0674	-2.7575	-0.5409	1.0947	-3.9861	-0.5428	0.1039
GB RBS	-0.0085	3.8007	0.3134	-0.0018	-0.1502	-0.9432	0.5173	0.1068	-4.9972	-0.9879	0.1602
ES Banco Populare Espanol	-0.022	1.0326	1.9198	-0.0005	0.0667	-4.4508	0.2617	1.1851	-2.4733	0.8074	0.0465
IT Intesa Sanpaolo	0.0155	-9.2215	-3.4438	-0.0033	0.397	1.857	-1.3857	-1.2353	-9.9965	2.6037	0.2824
IT Banco Populare	0.0024	-4.6389	-3.3636	-0.0018	-0.0206	0.3208	-0.815	-1.3953	-5.946	-0.1529	0.1373
FR Crédit Agricole	-0.0203	-4.2105	-8.9486	-0.0014	-0.0048	-2.217	-0.5409	-2.9094	-3.6885	-0.0278	0.1629
IT Di Milano	-0.0344	6.6722	-3.9606	-0.0006	-0.1117	-5.0991	1.2803	-1.7691	-2.2711	-0.8926	0.0729
IE Bank of Ireland	-0.0176	4.6793	-0.023	-0.0012	0.1841	-2.7078	0.8808	-0.0099	-4.5023	1.5465	0.1969
PT Comercial Portugues	0.003	7.6942	0.2823	-0.0023	0.0631	0.4137	1.2943	0.109	-8.1638	0.4905	0.2325
IT Monte Dei Paschi	-0.0136	2.9211	0.581	-0.0019	0.2113	-1.3418	0.3474	0.1848	-4.4949	1.1506	0.1969
PT Espirito Santo	-0.0163	1.5391	-2.2304	-0.0002	0.1709	-3.5404	0.4133	-1.4014	-1.2605	2.1974	0.0779
GR National Greece	-0.0318	-14.3098	3.6031	-0.0011	0.2028	-2.9167	-1.6772	0.9869	-2.6115	1.0725	0.0797
AT Erste Group Bank	-0.0262	-6.9591	4.1406	-0.0009	0.4799	-2.9257	-0.9935	1.4412	-2.5611	2.9239	0.0862

FR Natixis	-0.0229	-10.5747	-3.0032	-0.0006	-0.0048	-2.1118	-1.2001	-0.9232	-1.4847	-0.0257	0.0727
DK Sydbank	-0.0107	-9.6189	4.1991	-0.0003	0.0374	-1.9917	-2.4198	2.4847	-1.4953	0.4005	0.0472
ES Sabadell	-0.0106	1.7258	2.9276	-0.0008	0.5024	-2.1435	0.4266	1.8861	-3.8355	5.4678	0.1686
DK Jyske	-0.0216	-9.7319	6.4266	-0.0004	0.3167	-3.1863	-1.5828	2.6253	-1.2808	2.6058	0.1038
FIN Pohjola	-0.0209	-8.8328	-2.1547	-0.001	-0.1308	-1.7725	-1.0287	-0.6049	-2.215	-0.6631	0.0603
CH Valiant	-0.0095	2.3046	1.0707	-0	0.0946	-6.3634	1.7944	2.048	-0.0735	3.318	0.0945
IT Popolare Emilia	-0.0196	-3.2469	1.0506	-0.0002	0.2723	-2.6973	-0.5909	0.4463	-0.6945	2.2463	0.0783
CH Cantonale Vaudoise	0.0105	-1.9069	-10.174	-0.0033	0.2217	0.6155	-0.1502	-1.903	-4.8884	0.7752	0.1912
IT Di Sondrio	-0.0132	-4.0745	1.2977	-0.0002	0.0896	-3.0879	-1.2064	0.9218	-0.8905	1.225	0.0454
mean values	-0.0105	-1.5983	0.3352	-0.0015	0.1252	-1.5517	-0.1807	0.246	-4.4942	0.9943	0.1526

Table 5.12: Quantile regression results for the CoVaR model for all banks, pre-crisis period 2002–2006 (with banks ordered from largest to smallest ΔCoVaR)

	Intercept	Bank system returns	Euribor	Corporate bond spread	VSTOXX	S&P returns	t-statistic						
Country/bank	$\hat{\alpha}$	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	$\hat{\beta}_4$	$\hat{\beta}_5$	t0	t1	t2	t3	t4	t5	R^2
ES Banco Santander	0.0021	0.4242	0.6537	-2.5509	-0.0009	0.081	0.7355	12.5918	0.2778	-2.8082	-7.7488	1.6691	0.5008
FR BNP Paribas	-0.0053	0.4108	-1.6318	0.1964	-0.0005	0.2007	-1.8304	12.9362	-0.7068	0.195	-3.9396	3.9969	0.5402
ES Bilbao BBVA	0.0024	0.4457	-0.8597	-1.5188	-0.0007	0.1073	0.9965	15.14	-0.4432	-1.8414	-7.3389	2.4151	0.574
DE Deutsche Bank	-0.0035	0.3835	2.9018	2.1767	-0.0005	0.1568	-1.446	14.7749	1.421	2.6194	-5.2801	3.3976	0.5329
SWE Svenska	-0.0091	0.4731	2.4123	-0.9842	-0.0004	0.0483	-3.3097	11.8428	0.9725	-1.1069	-3.8728	0.9557	0.4792
SWE Nordea	-0.0061	0.3761	-1.9691	0.173	-0.0006	-0.0154	-1.4782	8.1912	-0.6224	0.1297	-3.7953	-0.2171	0.4446
FR Société Générale	-0.0028	0.3675	-1.209	0.6252	-0.0005	0.1865	-0.8992	11.1515	-0.4614	0.6322	-4.2233	3.5722	0.5329
CH Credit Suisse	-0.0053	0.2819	0.1074	0.0446	-0.0005	-0.029	-1.6134	9.6027	0.0402	0.0401	-3.9416	-0.4859	0.4743
DK Danske Bank	0.003	0.4825	-3.1495	-0.3067	-0.0012	-0.0357	1.0497	10.8378	-1.3154	-0.3092	-10.225	-0.7165	0.3918
IT Unicredit	-0.004	0.3742	-4.1858	2.2901	-0.0008	0.1802	-0.9062	6.5652	-1.1927	1.6584	-4.4688	2.4075	0.3856
CH UBS	-0.0012	0.3919	-3.1823	0.9168	-0.0007	0.1132	-0.4901	11.9591	-1.4891	1.1429	-6.3971	2.4007	0.523
GB HSBC	-0.0001	0.4761	-2.9851	3.8369	-0.001	0.075	-0.011	5.4433	-0.7815	2.4479	-5.2485	0.9042	0.3493
NOR DNB	-0.0021	0.3362	-1.361	0.3596	-0.0009	0.1649	-0.6676	8.8825	-0.5145	0.3628	-7.476	2.9871	0.3937
SWE Swedbank	-0.0031	0.3916	0.0796	0.3591	-0.0008	0.1565	-0.7934	7.0403	0.0237	0.2611	-4.8701	2.1538	0.4174
DE Commerzbank	-0.0104	0.2496	2.7448	1.7882	-0.0003	0.0365	-3.278	9.1337	0.9841	1.6277	-2.337	0.6382	0.487
GB Lloyds	-0.0035	0.286	-5.61	-0.1887	-0.0007	0.1728	-0.7906	5.5911	-1.5707	-0.1356	-3.9134	2.1834	0.3704
GB Barclays	0.0001	0.2967	-2.7001	-0.2865	-0.0007	0.1186	0.0279	5.8281	-0.8392	-0.2065	-3.9798	1.6914	0.3982
IT Mediobanca	-0.0038	0.3889	-0.7464	-1.4525	-0.0008	-0.0012	-0.9824	7.5765	-0.249	-1.1839	-5.094	-0.0191	0.4301
BE KBC	-0.006	0.2863	-0.7746	0.1773	-0.0006	0.1174	-1.9916	6.8415	-0.2947	0.1722	-4.487	2.0939	0.4323
GB StandardChartered	-0.0047	0.318	-1.6528	2.7269	-0.0006	0.0708	-0.8941	5.4703	-0.4391	1.6696	-3.0545	0.8357	0.3813

GB RBS	-0.0029	0.2973	-2.0597	2.6332	-0.0007	0.1549	-0.8903	6.7378	-0.7414	2.3625	-5.0168	2.564	0.4222
ES Banco Populare Espanol	0.0069	0.4095	-3.1253	2.5559	-0.0012	0.2304	2.0077	6.0665	-1.1322	2.1128	-9.2296	3.788	0.4049
IT Intesa Sanpaolo	-0.0074	0.2218	0.8752	2.6556	-0.0005	0.1015	-2.0168	6.6445	0.3027	2.1838	-3.2922	1.5237	0.4279
IT BancoPopulare	-0.0036	0.3622	-1.3288	2.3701	-0.0009	0.0657	-0.8898	6.2441	-0.4662	1.8694	-5.653	0.9595	0.3837
FR Crédit Agricole	-0.0003	0.2587	-2.4485	2.2679	-0.001	-0.0043	-0.1051	7.2784	-0.9642	2.2641	-8.5022	-0.0809	0.3779
ITDi Milano	-0.0001	0.2714	-5.6461	-0.2254	-0.001	0.0719	-0.0357	5.1496	-1.7338	-0.156	-6.0536	0.9832	0.3438
IE Bank of Ireland	0.007	0.2946	-6.4086	2.5753	-0.0013	0.0658	2.1443	6.4307	-2.2394	2.2954	-9.2769	1.1011	0.3569
PT Comercial Portugues	0.0036	0.2533	-4.9947	3.2048	-0.0013	0.0609	0.9181	5.077	-1.6112	2.3335	-8.3764	0.8978	0.299
IT Monte Dei Paschi	-0.0047	0.1997	-3.6439	2.8941	-0.0007	0.1291	-1.3715	5.3552	-1.2436	2.5657	-5.3237	2.1135	0.391
PT EspiritoSanto	0.0053	0.4908	-5.7123	4.2401	-0.0013	0.0739	1.5774	4.7746	-2.1323	3.7056	-9.3881	1.207	0.3499
GR National Greece	-0.0017	0.1619	-4.3546	-0.1742	-0.001	0.1269	-0.426	4.2559	-1.3246	-0.127	-6.5494	1.8975	0.3336
AT Erste Group Bank	0.0012	0.1537	-6.1936	4.3123	-0.0011	0.0886	0.3243	3.9529	-1.9467	3.5876	-7.5491	1.48	0.319
FR Natixis	-0.0006	0.21	-2.7609	1.6117	-0.001	0.1542	-0.1832	4.1607	-1.0002	1.4719	-7.0995	2.6565	0.3431
DK Sydbank	0.0003	0.29	-4.2508	1.2019	-0.0012	0.1205	0.0863	4.0298	-1.4865	1.0349	-8.3109	1.9252	0.3452
ES Sabadell	0.0047	0.2071	-7.4138	3.6602	-0.0013	0.0178	1.1269	2.5852	-2.386	2.8579	-8.0001	0.2619	0.3075
DK Jyske	0.0048	0.1704	-6.6776	2.9685	-0.0014	0.0812	1.3966	2.9847	-2.4307	2.7286	-10.209	1.3064	0.3305
FIN Pohjola	-0.0014	0.1225	-5.1244	2.2095	-0.0011	0.0892	-0.2697	1.6986	-1.2565	1.2851	-5.3969	1.0311	0.2818
CH Valiant	-0.002	0.4676	-9.2745	4.8529	-0.0012	0.0572	-0.5158	2.3432	-3.0097	3.916	-7.5656	0.7822	0.2681
IT Popolare Emilia	0.0018	0.1705	-6.3791	3.5763	-0.0012	0.1175	0.4303	1.5009	-1.7477	2.6255	-7.2714	1.5584	0.2798
CH Cantonale Vaudoise	0.0037	0.0264	-7.5572	3.7726	-0.0013	0.1075	0.8186	0.6412	-2.0816	2.5955	-7.2093	1.4448	0.2615
IT Di Sondrio	0.0018	-0.04	-6.6082	3.5706	-0.0012	0.163	0.4162	-0.322	-1.8579	2.4508	-7.1634	2.0555	0.2584
mean values	-0.0011	0.3034	-3.0294	1.5882	-0.0009	0.097	-0.3422	6.7071	-0.968	1.252	-6.1983	1.5688	0.3933

Table 5.13: OLS regression results for regression of the average ΔCoVaR on the VaR for all banks, pre-crisis period 2002–2006

Parameter	Estimate	Standard error	t-statistic
$\hat{\alpha}$	-0.0033	0.003	-1.104
$\hat{\beta}_1$	0.242	0.0623	3.8868

Table 5.14: Median VaR, Distressed VaR, and ΔCoVaR for all banks ordered from largest to smallest ΔCoVaR, crisis period 2007–2009 (average over time)

Country/Bank	MedianVaR	DistressedVaR	ΔCoVaR
IT Intesa Sanpaolo	0.0006	-0.1224	-0.1043
FR Crédit Agricole	-0.0029	-0.1377	-0.0991
GB HSBC	-0.0027	-0.0946	-0.097
ES Bilbao BBVA	0.0037	-0.1096	-0.0927
IT Unicredit	0.0058	-0.1399	-0.0918
FR Société Générale	-0.0055	-0.1421	-0.0902
DE Deutsche Bank	-0.007	-0.1429	-0.0876
SWE Swedbank	-0.0076	-0.1665	-0.0855
BE KBC	-0.0026	-0.1975	-0.0834
FR BNP Paribas	-0.0036	-0.1333	-0.083
ES Banco Santander	0.0019	-0.0995	-0.0825
IT Mediobanca	-0.0012	-0.0816	-0.0817
IT Banco Populare	-0.0055	-0.1429	-0.0791
DK Jyske	-0.0058	-0.087	-0.0776
CH UBS	-0.0068	-0.124	-0.077
DK Sydbank	-0.0012	-0.0961	-0.0758
IT Monte Dei Paschi	-0.0036	-0.0981	-0.0755
ES Banco Populare Espanol	-0.0048	-0.117	-0.0745
IT Popolare Emilia	-0.0058	-0.0734	-0.0721
DK Danske Bank	-0.0077	-0.1109	-0.0719
GB Standard Chartered	-0	-0.1185	-0.0716
GR National Greece	-0.0028	-0.1048	-0.0695
AT Erste Group Bank	-0.0145	-0.1525	-0.0689
SWE Nordea	-0.0036	-0.0891	-0.0663
IE Bank of Ireland	-0.0191	-0.2498	-0.0662
GB Barclays	-0.0113	-0.204	-0.0656
IT Di Sondrio	-0.003	-0.0623	-0.0656
SWE Svenska	0.0051	-0.0955	-0.0644
CH Credit Suisse	0.0032	-0.1152	-0.064
IT Di Milano	-0.0025	-0.0905	-0.0633
PT Espirito Santo	-0.0066	-0.0796	-0.0623
DE_Commerzbank	-0.0099	-0.1622	-0.0612
GB_RBS	-0.0144	-0.1892	-0.0609
FIN_PohjolaDEAD	-0.003	-0.1062	-0.0597
NOR DNB	-0.0053	-0.1276	-0.0586
ES Sabadell	-0.0042	-0.0784	-0.0577
GB Lloyds	-0.0071	-0.1689	-0.0555
PT Comercial Portugues	-0.0111	-0.0947	-0.054
CH Cantonale Vaudoise	0.0033	-0.0834	-0.0493
FR Natixis	-0.02	-0.1568	-0.0387
CH Valiant	0.0016	-0.0164	0.0045

Table 5.15: Median VaR, Distressed VaR, and ΔCoVaR for all countries ordered from largest to smallest ΔCoVaR, crisis period 2007–2009 (average over time)

Country	MedianVaR	DistressedVaR	ΔCoVaR
Belgium	-0.0026	-0.1975	-0.0834
Italy	-0.0019	-0.1014	-0.0792
France	-0.008	-0.1425	-0.0778
Spain	-0.0009	-0.1011	-0.0769
Denmark	-0.0049	-0.098	-0.0751
Germany	-0.0084	-0.1525	-0.0744
Sweden	-0.002	-0.117	-0.0721
United Kingdom	-0.0071	-0.1551	-0.0701
Greece	-0.0028	-0.1048	-0.0695
Austria	-0.0145	-0.1525	-0.0689
Ireland	-0.0191	-0.2498	-0.0662
Finland	-0.003	-0.1062	-0.0597
Norway	-0.0053	-0.1276	-0.0586
Portugal	-0.0089	-0.0872	-0.0582
Switzerland	0.0003	-0.0848	-0.0464

Table 5.16: Quantile regression results for the distress VaR model for all banks, crisis period 2007–2009 (with banks ordered from largest to smallest ΔCoVaR)

	Intercept	Euribor	Corporate bond spread	VSTOXX	S&P returns	t-statistic					
Country/bank	$\hat{\alpha}$	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	$\hat{\beta}_4$	t0	t1	t2	t3	t4	R^2
IT Intesa Sanpaolo	-0.0187	-8.6653	-6.6882	-0.0036	0.8889	-0.527	-0.8974	-1.3636	-2.8567	2.4926	0.2505
FR Crédit Agricole	0.0233	-9.0477	-3.5859	-0.0056	0.521	1.169	-1.5447	-1.1665	-7.7362	2.5522	0.2676
GB HSBC	0.0155	1.5162	-1.4796	-0.0037	0.8168	0.9541	0.3268	-0.5593	-5.9092	4.357	0.3333
ES Bilbao BBVA	0.0113	-14.5632	-2.1088	-0.0043	0.815	0.6284	-2.772	-0.7368	-6.4887	4.1959	0.3583
IT Unicredit	0.0152	-9.3397	-1.504	-0.0054	0.6337	0.5168	-0.9912	-0.3004	-4.83	1.8571	0.3142
FR Société Générale	0.0077	-5.959	-7.675	-0.0052	0.4921	0.3099	-0.9012	-2.2405	-5.9498	2.0476	0.3067
DE Deutsche Bank	0.0432	-13.6532	-11.9477	-0.0066	-0.0242	1.3379	-1.6507	-2.5956	-5.6077	-0.0772	0.3009
SWE Swedbank	0.0662	-16.9003	-4.6174	-0.0083	-0.27	2.5113	-2.2593	-1.2322	-8.9299	-1.0267	0.3234
BE KBC	0.1132	-16.7922	-0.4362	-0.0109	1.2665	2.4749	-1.2712	-0.0689	-5.9749	2.4787	0.2937
FR BNP Paribas	0.0114	15.2817	-1.9334	-0.0048	0.7577	0.4645	2.2531	-0.5622	-5.4403	3.0545	0.3517
ES Banco Santander	0.0212	-12.3033	-3.5428	-0.0043	0.4892	1.0876	-2.1654	-1.2477	-6.1334	2.4811	0.4
IT Mediobanca	-0.0469	-3.5414	0.5375	-0.0012	0.2355	-1.7255	-0.489	0.147	-1.2723	0.9115	0.0659
IT Banco Populare	0.0646	-1.3878	-10.614	-0.0072	-0.7786	2.7227	-0.1939	-2.984	-7.8026	-3.1064	0.2949
DK Jyske	0.0216	-2.3021	-6.0613	-0.0037	0.3427	1.313	-0.4916	-2.7259	-6.1819	2.1177	0.4042
CH UBS	0.0149	-13.0728	-1.2161	-0.0049	0.4885	0.4886	-1.5481	-0.2976	-4.6172	1.5271	0.2477
DK Sydbank	0.0068	-13.9995	-10.399	-0.0037	0.4489	0.2459	-1.711	-2.7851	-3.529	1.5655	0.354
IT Monte Dei Paschi	0.0001	-4.5953	-0.8119	-0.0034	0.4693	0.005	-0.5949	-0.2073	-3.423	1.7221	0.1625
ES Banco Populare Espanol	-0.0206	-7.5447	-4.7286	-0.0034	0.1786	-0.8825	-1.0928	-1.3467	-3.9989	0.7167	0.1817
IT Popolare Emilia	0.0071	-8.1928	3.9087	-0.0029	0.397	0.5165	-2.2316	1.9619	-5.7553	2.8764	0.1796
DK Danske Bank	0.0015	-12.8425	-5.3789	-0.004	0.6441	0.0541	-1.6152	-1.3281	-3.8444	2.188	0.3359
GB Standard Chartered	0.0067	-5.8401	-9.1309	-0.0044	-0.1809	0.1939	-0.6444	-1.924	-3.6203	-0.5174	0.3042
GR National Greece	0.0188	-4.4287	-6.756	-0.0043	-0.2896	0.6169	-0.539	-1.7003	-3.838	-0.9492	0.3613
AT Erste Group Bank	0.0826	-16.9173	-0.7344	-0.0083	0.6203	2.8057	-2.0453	-0.1676	-7.6206	2.0427	0.2964
SWE Nordea	0.029	4.844	-4.5015	-0.004	0.1264	1.0421	0.6702	-1.2093	-4.0248	0.4531	0.2729
IE Bank of Ireland	0.1407	-27.3192	-7.7848	-0.0138	1.0423	2.9054	-1.9129	-1.1294	-7.4495	2.044	0.3321
GB Barclays	0.0919	29.3173	-15.6264	-0.0098	0.0844	1.5883	1.9064	-2.0062	-4.6697	0.1403	0.2247
IT DiSondrio	0.0114	-6.7004	0.2788	-0.0026	0.3888	0.9586	-1.92	0.1534	-5.9982	3.2014	0.2017
SWE Svenska	0.001	-5.3466	-2.8932	-0.0034	0.4541	0.041	-0.7914	-0.8528	-3.9424	2.0139	0.2918
CH Credit Suisse	0.0166	-8.9672	-12.4169	-0.0046	-0.1166	0.5592	-1.0388	-2.7955	-4.1566	-0.4046	0.3083
IT Di Milano	-0.0301	-4.3777	0.5298	-0.0021	0.2793	-1.0131	-0.525	0.127	-1.8658	0.9091	0.0891
PT Espirito Santo	0.0027	1.6968	-0.3863	-0.0028	0.152	0.1321	0.2946	-0.1298	-3.7586	0.7126	0.2732
DE Commerzbank	0.0736	-4.3401	-13.1715	-0.0082	-0.9305	1.4775	-0.3727	-2.0667	-4.8611	-1.9841	0.1901

GB RBS	0.1064	-2.9991	-8.9012	-0.0102	0.3962	1.6021	-0.1687	-0.9557	-3.5681	0.5291	0.176
FIN Pohjola	0.0067	-14.974	-0.4837	-0.0041	-0.0986	0.2985	-2.3111	-0.154	-5.0118	-0.4238	0.2357
NOR DNB	0.0475	-11.9697	-5.8112	-0.0061	0.9101	1.9347	-1.6689	-1.6173	-6.8189	3.4899	0.2903
ES Sabadell	-0.0332	5.941	-3.5137	-0.0015	-0.0977	-1.9697	1.2093	-1.4359	-2.3321	-0.5524	0.152
GB Lloyds	0.1302	-2.8498	-2.0399	-0.0104	0.3254	2.8127	-0.2224	-0.336	-5.9625	0.6059	0.3079
PT Comercial Portugues	-0.0652	0.7171	-7.9635	-0.0009	0.5646	-4.1741	0.16	-3.4738	-1.6271	3.4092	0.2482
CH Cantonale Vaudoise	-0.032	-17.1724	-0.0785	-0.002	0.4926	-1.4632	-3.0539	-0.0275	-2.5866	2.3228	0.198
FR Natixis	-0.0073	-8.6942	6.4783	-0.0052	0.9367	-0.2397	-1.0118	1.4535	-4.8314	2.9484	0.1964
CH Valiant	-0.0072	0.0985	-2.4931	-0.0003	-0.0261	-1.7507	0.0905	-4.3613	-2.1193	-0.6497	0.098
mean values	0.0231	-6.2972	-4.3337	-0.005	0.3377	0.5372	-0.8716	-1.128	-4.8035	1.3237	0.2628

Table 5.17: Quantile regression results for the CoVaR model for all banks, crisis period 2007–2009 (with banks ordered from largest to smallest ΔCoVaR)

	Intercept	Bank system returns	Euribor	Corporate bond spread	VSTOXX	S&P returns	t-statistic						
Country/Bank	$\hat{\alpha}$	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	$\hat{\beta}_4$	$\hat{\beta}_5$	t0	t1	t2	t3	t4	t5	R^2
IT Intesa Sanpaolo	0.003	0.8482	4.1536	2.3786	-0.0021	0.4394	0.2428	13.8142	1.2587	1.4537	-4.7577	3.5994	0.6226
FR Crédit Agricole	0.0241	0.7353	1.0981	-0.821	-0.0026	0.2946	2.7322	17.2974	0.4281	-0.6373	-8.1916	3.2621	0.6604
GB HSBC	0.0161	1.0549	-10.494	2.6903	-0.0027	0.451	1.7266	17.9529	-3.8094	1.9657	-7.9944	4.6479	0.6446
ES Bilbao BBVA	0.0038	0.8182	-3.6898	0.2569	-0.0018	0.2707	0.3754	14.3337	-1.277	0.1725	-4.9444	2.4447	0.694
IT Unicredit	0.0024	0.6302	2.4624	1.941	-0.0018	0.1223	0.2165	13.3563	0.8292	1.2497	-4.3256	1.1171	0.6347
FR Société Générale	0.0183	0.6606	-4.3144	-0.9866	-0.0024	0.0791	1.8062	16.1214	-1.4111	-0.6806	-6.2066	0.7235	0.6428
DE Deutsche Bank	0.0263	0.6443	4.174	-0.8581	-0.0026	-0.0503	3.1357	19.6027	1.9911	-0.797	-8.7943	-0.6359	0.6828
SWE Swedbank	0.0124	0.5387	-10.998	3.511	-0.0027	0.1634	1.012	12.5814	-3.2168	1.9737	-6.1391	1.3316	0.6038
BE KBC	-0.0237	0.4279	2.4395	-1.8006	-0.0008	-0.3193	-2.6654	15.7079	0.9067	-1.3755	-2.4706	-3.3065	0.6869
FR BNP Paribas	0.0184	0.6395	-3.9681	0.0699	-0.0023	-0.0006	1.5556	11.2742	-1.2705	0.041	-4.9417	-0.0046	0.6208
ES Banco Santander	-0.0077	0.8136	0.6845	-0.4745	-0.0013	0.2792	-0.4083	8.9578	0.1581	-0.2099	-2.1142	1.8066	0.6288
IT Mediobanca	-0.0167	1.0162	4.0194	-2.9776	-0.0014	0.38	-1.0464	9.2189	0.9588	-1.342	-2.2481	2.4172	0.5548
IT Banco Populare	0.0112	0.5758	-5.3519	-4.6163	-0.0024	-0.0287	0.7697	11.5622	-1.4039	-2.2775	-4.6402	-0.2048	0.595
DK Jyske	-0.0013	0.956	2.5808	-4.42	-0.0023	-0.0714	-0.1062	13.0442	0.7247	-2.4766	-5.0243	-0.542	0.5571
CH UBS	0.0006	0.6569	-0.5036	-3.2609	-0.002	-0.0471	0.0398	9.477	-0.1202	-1.6345	-3.4789	-0.3019	0.5514
DK Sydbank	-0.0203	0.7992	10.5622	-1.8127	-0.0016	-0.3855	-1.2758	9.4842	2.368	-0.755	-2.6581	-2.3526	0.5494
IT Monte Dei Paschi	0.037	0.7993	-5.1623	-2.1703	-0.0038	0.1447	2.8599	10.3393	-1.4964	-1.1812	-8.3462	1.2091	0.5629
ES Banco Populare Espanol	0.0042	0.6648	-6.7597	-1.2091	-0.0021	0.4446	0.2731	8.662	-1.6271	-0.5861	-3.6548	2.6867	0.5944

IT Popolare Emilia	0.0057	1.0671	-5.713	-6.3072	-0.0028	-0.0723	0.5367	15.2928	-1.8617	-4.1712	-6.9897	-0.6656	0.5552
DK Danske Bank	0.0149	0.6968	3.1942	4.9809	-0.0025	-0.1442	1.9638	18.5852	1.4676	4.268	-8.8209	-1.7633	0.653
GB Standard Chartered	0.0109	0.6046	-6.5231	7.0173	-0.0028	0.8156	0.8549	10.2681	-1.8771	3.8476	-5.607	5.9052	0.531
GR National Greece	0.0124	0.6821	-11.970	2.103	-0.0031	0.5465	1.1583	13.9632	-3.7711	1.2474	-7.9097	4.5832	0.549
AT Erste Group Bank	-0.0082	0.4991	5.9122	2.0923	-0.0013	0.4124	-0.5308	9.3684	1.3198	0.9354	-2.0891	2.6226	0.6004
SWE Nordea	0.0007	0.7755	0.6246	-3.1067	-0.0018	-0.0409	0.0709	14.1455	0.2234	-2.0718	-4.6645	-0.3872	0.664
IE Bank of Ireland	0.0145	0.2869	4.4056	-0.6928	-0.003	0.4767	1.193	11.2088	1.3112	-0.3945	-7.0033	3.7177	0.54
GB Barclays	0.0338	0.3405	-0.6766	1.953	-0.0034	0.363	2.65	10.3747	-0.2046	1.052	-7.5511	2.9757	0.5739
IT Di Sondrio	-0.0045	1.1063	-2.9074	-4.3647	-0.0024	0.4529	-0.3613	9.2066	-0.7745	-2.2376	-5.1522	3.4066	0.5075
SWE Svenska	0.0263	0.6397	-8.6873	1.5964	-0.0034	-0.0646	1.9044	8.381	-2.2263	0.8391	-6.4714	-0.4313	0.563
CH Credit Suisse	0.015	0.5405	4.0873	3.995	-0.0025	0.3448	1.2223	10.4445	1.1798	2.2228	-5.4013	2.8194	0.6243
IT Di Milano	-0.0199	0.7186	8.4994	-2.9862	-0.0011	0.3371	-1.7763	11.916	2.8074	-1.8434	-2.714	2.883	0.6433
PT Espirito Santo	0.0297	0.8546	-9.9394	-3.8297	-0.004	0.3986	2.623	9.9709	-2.9074	-2.0839	-9.546	3.1551	0.4928
DE Commerzbank	0.0385	0.4021	-7.0901	3.0961	-0.0038	0.4158	3.6547	9.2888	-2.1356	1.8595	-9.3161	3.3392	0.544
GB RBS	0.0022	0.3483	11.9287	0.1089	-0.0017	-0.0242	0.1112	8.91	2.8034	0.0428	-2.4658	-0.143	0.5405
FIN Pohjola	0.0118	0.5786	0.7603	0.6697	-0.0032	0.457	0.7462	6.5349	0.1618	0.2995	-5.4866	2.6913	0.4964
NOR DNB	0.0007	0.4793	0.1389	0.3232	-0.0022	0.0492	0.0588	8.6682	0.0408	0.1841	-4.7822	0.3766	0.5976
ES Sabadell	0.0095	0.7773	-6.3676	0.6629	-0.0024	0.0904	0.6856	6.3672	-1.4422	0.3188	-4.3444	0.5639	0.5333
GB Lloyds	0.0177	0.3431	-6.8235	-2.1474	-0.0031	0.0744	1.0037	7.8592	-1.5539	-0.8681	-5.0715	0.4542	0.5365
PT Comercial Portugues	0.0085	0.6459	0.0618	-3.8791	-0.0032	-0.2123	0.4921	7.3642	0.0132	-1.5354	-5.1801	-1.1914	0.4459
CH Cantonale Vaudoise	0.0582	0.568	-4.8007	-3.3068	-0.0056	-0.281	3.9921	5.9595	-1.0958	-1.5814	-10.216	-1.7832	0.4011
FR Natixis	0.0336	0.2828	-1.6472	-6.9652	-0.0036	-0.0283	2.0122	4.8408	-0.3658	-3.2157	-5.6024	-0.1762	0.4737
CH Valiant	0.0182	-0.2524	0.7359	1.4394	-0.0037	0.5374	0.9443	-0.4686	0.1435	0.4995	-4.957	2.4434	0.3335
mean values	0.0107	0.6406	-1.265	-0.5392	-0.0026	0.1724	0.8891	11.0058	-0.3598	-0.2313	-5.5676	1.2998	0.5729

Table 5.18: OLS regression results for regression of the average ΔCoVaR on the VaR for all banks, crisis period 2007–2009

Parameter	Estimate	Standard error	t-statistic
$\hat{\alpha}$	-0.0571	0.0085	-6.7184
$\hat{\beta}_1$	0.1128	0.0662	1.704

Table 5.19: Median VaR, Distressed VaR, and ΔCoVaR for all banks ordered from largest to smallest ΔCoVaR, post-crisis period 2010–2014 (average over time)

Country/Bank	MedianVaR	DistressedVaR	ΔCoVaR
GB RBS	0.0045	-0.1106	-0.0631
IT Unicredit	0.0001	-0.1089	-0.061
FR BNP Paribas	0.0042	-0.0828	-0.0602
FR Société Générale	0.0007	-0.1062	-0.0581
IT Mediobanca	0.0032	-0.0971	-0.058
AT Erste Group Bank	0.0011	-0.0953	-0.0576
DE Commerzbank	-0.0027	-0.1005	-0.0563
IT Banco Populare	-0.0009	-0.122	-0.0562
GB Barclays	0.0016	-0.0993	-0.0559
IT Intesa Sanpaolo	0.0025	-0.0903	-0.0544
CH Credit Suisse	-0.0024	-0.0766	-0.0539
ES Banco Santander	0.0047	-0.0748	-0.053
BE KBC	0.0049	-0.1101	-0.0529
GB Lloyds	0.0077	-0.0947	-0.0528
IT Popolare Emilia	-0.0017	-0.1055	-0.0524
ES Bilbao BBVA	0.0001	-0.0798	-0.0506
FR Crédit Agricole	0.0004	-0.1029	-0.0491
SWE Svenska	0.0057	-0.0491	-0.0487
ES Banco Populare Espanol	-0.0039	-0.1017	-0.0478
FR Natixis	0.0063	-0.0787	-0.0464
CH UBS	-0.0006	-0.0677	-0.0463
IT Di Milano	-0.0064	-0.1293	-0.0458
IT Di Sondrio	-0.0069	-0.0754	-0.0456
DK Jyske	0.0031	-0.0652	-0.0452
DE Deutsche Bank	-0.0034	-0.0746	-0.0442
SWE Nordea	0.0031	-0.0626	-0.0421
DK Danske Bank	0.0036	-0.0679	-0.0419
PT Espirito Santo	-0.0019	-0.1219	-0.0417
GB HSBC	0.0025	-0.0473	-0.0409
NOR DNB	0.0032	-0.0694	-0.0408
FIN Pohjola	0.0039	-0.0553	-0.0392
IE Bank of Ireland	0.0028	-0.1409	-0.0392
GB Standard Chartered	0.0022	-0.0627	-0.0377
ES Sabadell	-0.0026	-0.0861	-0.037
IT Monte Dei Paschi	-0.0105	-0.127	-0.0359
SWE Swedbank	0.0046	-0.064	-0.0356
DK Sydbank	0.0005	-0.0599	-0.0347
CH Cantonale Vaudoise	0.0031	-0.0444	-0.0338
PT Comercial Portugues	-0.003	-0.129	-0.0267
GR National Greece	-0.015	-0.1976	-0.0254
CH Valiant	0.0009	-0.0516	-0.02

Table 5.20: Median VaR, Distressed VaR, and ΔCoVaR for all countries ordered from largest to smallest ΔCoVaR, post-crisis period 2010–2014 (average over time)

Country	MedianVaR	DistressedVaR	ΔCoVaR
Austria	0.0011	-0.0953	-0.0576
France	0.0029	-0.0926	-0.0534
Belgium	0.0049	-0.1101	-0.0529
Italy	-0.0026	-0.1069	-0.0512
Germany	-0.0031	-0.0876	-0.0502
United Kingdom	0.0037	-0.0829	-0.0501
Spain	-0.0004	-0.0856	-0.0471
Sweden	0.0045	-0.0586	-0.0421
Norway	0.0032	-0.0694	-0.0408
Denmark	0.0024	-0.0643	-0.0406
Finland	0.0039	-0.0553	-0.0392
Ireland	0.0028	-0.1409	-0.0392
Switzerland	0.0002	-0.0601	-0.0385
Portugal	-0.0024	-0.1254	-0.0342
Greece	-0.015	-0.1976	-0.0254

Table 5.21: Quantile regression results for the distress VaR model for all banks, post-crisis period 2010–2014 (with banks ordered from largest to smallest ΔCoVaR)

	Intercept	Euribor	Corporate bond spread	VSTOXX	S&P returns	t-statistic					
Country/Bank	$\hat{\alpha}$	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	$\hat{\beta}_4$	t0	t1	t2	t3	t4	R^2
GB RBS	-0.0181	-6.7617	-5.8421	-0.0041	1.3127	-0.7978	-0.4261	-1.5334	-4.4559	4.2413	0.1192
IT Unicredit	0.0155	13.632	-9.8551	-0.0052	-0.3677	0.5903	0.7306	-2.1822	-4.6878	-1.0251	0.1267
FR BNP Paribas	0.0089	-23.6725	-5.1484	-0.0039	-0.2631	0.5418	-1.8829	-1.7132	-5.566	-1.0549	0.1637
FR Société Générale	0.0144	-20.6313	-9.367	-0.0052	-0.0097	0.612	-1.1591	-2.3073	-5.1746	-0.0314	0.1627
IT Mediobanca	-0.0661	-8.0261	2.6665	-0.0015	0.8125	-2.9567	-0.4626	0.6772	-1.5601	2.3725	0.0232
AT Erste Group Bank	0.0198	-1.4367	-0.5694	-0.0049	-0.1071	0.9024	-0.0826	-0.1403	-5.3228	-0.3117	0.1726
DE Commerzbank	-0.0535	-28.778	-1.3916	-0.0021	0.3239	-2.0205	-1.4824	-0.2819	-1.9162	0.8044	0.0716
IT Banco Populare	-0.0777	-10.21	2.6295	-0.002	0.9205	-3.6321	-0.639	0.6559	-2.3113	2.7718	0.0621
GB Barclays	-0.0218	-4.559	-0.8188	-0.0035	1.1758	-1.0058	-0.2886	-0.2102	-3.8047	3.8241	0.0883
IT Intesa Sanpaolo	0.0023	-0.6562	-2.962	-0.004	0.1314	0.1314	-0.0477	-1.0606	-5.0123	0.4936	0.1055
CH Credit Suisse	0.0058	1.0374	1.3812	-0.0035	-0.1368	0.3975	0.0873	0.5088	-5.4675	-0.5787	0.1326
ES Banco Santander	-0.0236	-13.0072	-2.7025	-0.0022	-0.1311	-1.1056	-0.863	-0.7902	-2.5254	-0.4164	0.0355
BE KBC	0.0749	-0.066	-0.235	-0.0079	-0.2227	2.8098	-0.0033	-0.0503	-6.9331	-0.592	0.1716
GB Lloyds	0.0123	-28.4057	-7.199	-0.0047	0.6073	0.4901	-1.442	-1.686	-4.2698	1.7212	0.1157
IT Popolare Emilia	-0.0969	50.308	0.4085	-0.0003	0.3164	-4.5876	3.1452	0.1099	-0.334	1.035	0.0209
ES Bilbao BBVA	-0.0373	-4.8057	0.6468	-0.0019	0.149	-1.6874	-0.3169	0.1703	-2.0232	0.49	0.0413
FR Crédit Agricole	0.0117	-8.688	-6.2425	-0.0048	-0.8051	0.5357	-0.6008	-1.7217	-5.0941	-2.7408	0.1155
SWE Svenska	0.0021	-8.9162	-1.241	-0.0023	0.5869	0.1637	-0.9655	-0.5597	-4.0508	3.3304	0.113
ES Banco Populare Espanol	-0.1106	19.7007	-9.268	0.0004	-0.0013	-4.7869	1.1068	-2.2918	0.4539	-0.0042	0.0313
FR Natixis	0.0036	-7.0078	0.339	-0.0035	-0.1924	0.2012	-0.5054	0.1011	-4.6896	-0.7232	0.1361
CH UBS	-0.0207	-2.0781	0.2598	-0.0021	0.511	-1.4188	-0.199	0.1059	-3.4713	2.3747	0.0755
IT DiMilano	-0.0184	-29.0356	-8.6224	-0.0048	0.2575	-0.6275	-1.2583	-1.545	-3.8523	0.5621	0.0649
IT DiSondrio	-0.0812	-12.1635	-3.6829	0.0003	-0.1201	-4.9742	-1.0088	-1.2937	0.3615	-0.54	0.0196
DK Jyske	-0.0022	-29.7903	-5.8427	-0.0028	0.4983	-0.1642	-2.9587	-2.5694	-4.7965	2.5264	0.1843
DE Deutsche Bank	-0.0223	-7.8301	-1.7334	-0.0023	0.4712	-1.8079	-0.8686	-0.8078	-4.3133	2.6679	0.1389
SWE Nordea	-0.0147	-19.0995	-1.514	-0.0021	0.4388	-0.7978	-1.441	-0.4646	-2.7668	1.7017	0.1158
DK Danske Bank	0.0277	-11.7118	-5.4724	-0.0042	0.4127	1.8344	-1.0699	-2.0985	-6.2978	2.1246	0.1739
PT Espirito Santo	-0.1579	24.2522	-10.2181	0.0017	-0.3327	-3.2427	0.7917	-1.3388	0.7178	-0.4821	0.0176
GB HSBC	-0.0274	0.4722	-1.469	-0.0008	-0.078	-1.9056	0.0497	-0.6522	-1.4367	-0.4111	0.0521

NOR DNB	-0.0199	-27.0446	-6.2431	-0.0022	0.3993	-1.1834	-2.1643	-2.2273	-3.174	1.658	0.1268
FIN Pohjola	-0.0287	-6.8678	-2.0527	-0.0012	0.3444	-1.6158	-0.5379	-0.6367	-1.6046	1.3641	0.047
IE Bank of Ireland	-0.0387	-18.9476	0.895	-0.0044	-0.1342	-0.8007	-0.5677	0.1111	-2.1781	-0.2109	0.0628
GB Standard Chartered	-0.0424	-12.206	-3.6692	-0.0009	-0.0271	-2.1234	-0.8328	-1.0542	-1.0304	-0.098	0.0228
ES Sabadell	-0.1063	-2.0319	-4.7226	0.0009	0.0242	-6.2287	-0.166	-1.564	1.2385	0.1047	0.0289
IT Monte Dei Paschi	-0.1169	-2.503	5.0838	-0.0005	0.5983	-3.3786	-0.1031	0.8282	-0.365	1.2876	0.0226
SWE Swedbank	-0.0065	-5.1278	-5.1127	-0.0025	0.6356	-0.3145	-0.3432	-1.3872	-2.8388	2.0746	0.1171
DK Sydbank	-0.0087	-17.6777	1.3223	-0.0023	0.6194	-0.5827	-1.6158	0.495	-3.8109	2.9543	0.1196
CH Cantonale Vaudoise	0.0028	-9.6742	-4.9463	-0.0021	0.297	0.1976	-0.9947	-2.158	-3.488	1.5643	0.1385
PT Comercial Portugues	-0.0902	-6.7691	-5.5633	-0.0016	-0.2113	-2.7282	-0.3031	-1.0621	-1.1823	-0.4599	0.048
GR National Greece	-0.1686	-63.2109	-18.8414	-0.0013	-0.1935	-2.7988	-1.4624	-1.9363	-0.5121	-0.2243	0.0243
CH Valiant	-0.0574	-4.4582	-9.807	0.0003	-0.0285	-4.3068	-0.4486	-4.2342	0.4838	-0.1566	0.08
mean values	-0.0325	-8.6452	-3.5786	-0.0025	0.2069	-1.3213	-0.5756	-0.9706	-2.904	0.829	0.09

Table 5.22: Quantile regression results for the CoVaR model for all banks, post-crisis period 2010–2014 (with banks ordered from largest to smallest ΔCoVaR)

	Intercept	Bank system returns	Euribor	Corporate bond spread	VSTOXX	S&P returns	t-statistic						
Country/Bank	$\hat{\alpha}$	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	$\hat{\beta}_4$	$\hat{\beta}_5$	t0	t1	t2	t3	t4	t5	R^2
GB RBS	-0.0337	0.5478	4.9108	0.9217	-0.0005	-0.0521	-3.1441	9.9575	0.6076	0.4678	-1.0306	-0.3394	0.3785
IT Unicredit	-0.0027	0.56	-9.0154	0.4737	-0.0014	0.0391	-0.3353	16.9229	-1.4342	0.3295	-4.0038	0.3383	0.5052
FR BNP Paribas	-0.0277	0.6928	-3.318	-2.5122	-0.0003	0.1501	-4.0168	16.6174	-0.6744	-2.0187	-0.949	1.5773	0.5677
FR Société Générale	-0.0011	0.5433	-2.6254	-1.7197	-0.0014	-0.025	-0.1183	14.8336	-0.4361	-1.2075	-3.9108	-0.2186	0.5501
IT Mediobanca	-0.0099	0.578	5.0859	-2.0988	-0.0013	0.0188	-1.2705	13.1686	0.8457	-1.5871	-4.0362	0.1652	0.4612
AT Erste Group Bank	-0.0371	0.5971	-2.169	1.5973	-0.0001	0.075	-3.9183	12.3197	-0.3243	0.9456	-0.1321	0.5666	0.4143
DE Commerzbank	-0.0493	0.5757	-1.7929	-1.343	0.0004	0.1465	-5.4067	13.2717	-0.2539	-0.8938	1.0324	1.0948	0.3843
IT Banco Populare	-0.0087	0.4644	-15.5974	-0.0393	-0.0016	0.0579	-0.7595	9.0522	-1.8408	-0.0189	-3.3811	0.3543	0.3798
GB Barclays	-0.0009	0.5544	-5.2008	0.6172	-0.0019	-0.1016	-0.1162	12.0036	-0.7296	0.4052	-5.3804	-0.8125	0.398
IT Intesa Sanpaolo	-0.0318	0.5868	17.3151	1.3377	-0.0003	-0.1313	-2.8281	10.3698	2.1333	0.7271	-0.6154	-0.8549	0.4804
CH Credit Suisse	-0.0184	0.7265	1.7412	1.8193	-0.0009	-0.0447	-2.0687	12.4819	0.2713	1.2027	-2.5941	-0.353	0.4513
ES Banco Santander	-0.0245	0.6667	16.8533	-2.0948	-0.0005	-0.0895	-2.9147	11.8272	2.6869	-1.355	-1.4333	-0.7387	0.5135
BE KBC	-0.0392	0.4601	-0.8258	-3.692	-0.0001	0.2227	-4.54	12.4966	-0.1241	-2.5292	-0.2396	1.8232	0.4642
GB Lloyds	-0.0271	0.5156	2.0332	-3.2612	-0.0008	0.101	-3.3666	11.127	0.3162	-1.9707	-2.4083	0.8236	0.4324
IT Popolare Emilia	0.0085	0.5048	-13.2304	-0.3386	-0.0025	-0.2473	0.5909	7.5268	-1.2754	-0.1343	-4.2386	-1.2603	0.2858
ES Bilbao BBVA	-0.0149	0.6332	8.2842	-1.686	-0.0008	0.1837	-1.8263	13.5087	1.4027	-1.1919	-2.3194	1.5573	0.54

FR Crédit Agricole	-0.0173	0.4757	-8.8643	-0.1379	-0.0008	0.1385	-2.1924	11.4418	-1.3706	-0.089	-2.3791	1.1631	0.5122
SWE Svenska	-0.0448	0.8877	6.5058	-1.3275	-0.0004	-0.3213	-3.8954	8.4661	0.812	-0.6726	-0.8336	-2.0786	0.3496
ES Banco Populare Espanol	-0.0135	0.4884	9.1399	0.3275	-0.0012	0.2613	-1.2864	9.3263	1.0939	0.1673	-2.8884	1.6704	0.3726
FR Natixis	-0.0302	0.5451	10.2614	-0.4438	-0.0005	0.0856	-2.4046	8.7148	1.2242	-0.2168	-0.854	0.5346	0.3929
CH UBS	-0.0174	0.69	-7.5292	-1.8441	-0.0011	-0.171	-1.7571	10.0867	-1.0476	-1.0797	-2.5428	-1.2707	0.384
IT Di Milano	-0.0082	0.3726	7.2065	-3.0065	-0.0017	0.0613	-0.5183	6.0299	0.6565	-1.1513	-2.6777	0.2767	0.2951
IT Di Sondrio	0.0068	0.6648	-12.8586	-0.1941	-0.0026	0.8284	0.6847	10.5686	-1.791	-0.1233	-6.1917	6.0095	0.3371
DK Jyske	-0.0315	0.6623	10.0939	2.3344	-0.001	-0.0531	-2.9499	8.3951	1.1386	1.1561	-2.1524	-0.3395	0.3397
DE Deutsche Bank	-0.0302	0.6201	-8.9587	-3.7257	-0.0003	0.095	-3.1458	10.4098	-1.2548	-2.2597	-0.8317	0.7234	0.4566
SWE Nordea	-0.0373	0.6401	8.6156	-0.0262	-0.0004	-0.1588	-3.6694	7.9987	1.1898	-0.0145	-1.0133	-1.0876	0.4112
DK Danske Bank	-0.0314	0.5861	14.0435	-1.6898	-0.0009	-0.2153	-3.9652	10.1294	2.262	-1.0945	-2.536	-1.8886	0.353
PT Espirito Santo	0.0028	0.3478	0.6959	1.0429	-0.002	-0.2099	0.2512	11.5067	0.0942	0.5859	-4.0968	-1.397	0.3111
GB HSBC	-0.0288	0.821	-23.3085	-3.0282	-0.0011	0.3788	-1.6642	4.6549	-1.8165	-0.9508	-1.5321	1.462	0.188
NOR DNB	-0.0302	0.5626	-7.6134	-3.0376	-0.0009	-0.3762	-2.4959	6.5505	-0.8186	-1.4776	-1.701	-2.1753	0.3191
FIN Pohjola	-0.0385	0.6629	1.4146	-2.9739	-0.0002	-0.0605	-3.5793	8.1075	0.1682	-1.5585	-0.5205	-0.3872	0.3808
IE Bank of Ireland	-0.039	0.2732	-19.0328	-0.6046	-0.0009	0.2007	-3.0321	6.8563	-1.9084	-0.2484	-1.708	1.0572	0.2383
GB Standard Chartered	-0.0221	0.5813	-10.2902	0.49	-0.0015	-0.1907	-1.4313	5.1169	-0.9043	0.1912	-2.3154	-0.8516	0.2141
ES Sabadell	0.0006	0.4429	6.4213	-4.5171	-0.0022	-0.0622	0.0503	6.9572	0.6313	-2.1001	-4.1736	-0.3468	0.2903
IT Monte Dei Paschi	-0.0477	0.308	18.0878	-3.6615	-0.0003	-0.1095	-3.1449	5.7459	1.7772	-1.43	-0.4275	-0.5312	0.2293
SWE Swedbank	-0.0429	0.5193	3.025	2.9036	-0.0006	-0.369	-4.0414	7.4545	0.3842	1.4903	-1.3784	-2.4122	0.3214
DK Sydbank	-0.0206	0.5744	0.5622	-1.3936	-0.0015	-0.1824	-1.9792	6.7111	0.0672	-0.7361	-3.2914	-1.1819	0.3346
CH Cantonale Vaudoise	-0.0401	0.7112	-13.7078	-1.1075	-0.0011	-0.2566	-2.6698	3.899	-1.2166	-0.4207	-1.7031	-1.1363	0.1641
PT Comercial Portugues	-0.0098	0.2122	24.4417	-3.7844	-0.0021	0.3293	-0.7928	3.9328	2.6349	-1.7057	-4.1772	1.7947	0.2069
GR National Greece	-0.012	0.1389	-10.8921	-5.4866	-0.002	0.0982	-0.9955	4.2069	-1.1295	-2.2453	-3.8949	0.4921	0.1704
CH Valiant	-0.0482	0.3812	-17.0232	-2.2887	-0.0006	0.3403	-2.9591	2.4582	-1.4005	-0.8111	-0.8303	1.4956	0.0988
mean values	-0.0232	0.5458	-0.4174	-1.2	-0.001	0.0094	-2.1859	9.3466	0.0158	-0.625	-2.251	0.0809	0.3629

Table 5.23: OLS regression results for regression of the average ΔCoVaR on the VaR for all banks, post-crisis period 2010–2014

Parameter	Estimate	Standard error	t-statistic
$\hat{\alpha}$	-0.0442	0.005	-8.7945
$\hat{\beta}_1$	0.0203	0.053	0.3829

6 Contingent capital part I: A critical literature review

This chapter extends the list of possible macro-prudential tools from chapter 4 with an analysis of contingent capital. Chapter 6 gives a critical literature review before chapter 7 gives an empirical analysis of a sample of already issued CoCos and a new CoCo proposal that fits into the recovery and resolution of a struggling bank.

6.1 Introduction

Contingent capital is unsecured debt in the form of a bond that is among the most junior among creditors' claims to a bank. Upon a predefined trigger event this bond increases the equity ratio of the bank. The affected bank would not need to finance itself with issuing equity directly in the primary financial markets and a bail-out by the government to avoid contagion is less likely. This can be done by a conversion into newly issued equity or a principal write-down of the bond that de-levers the bank. To avoid confusion about the notation, this chapter uses "contingent capital" as the general term to refer to either approach and "CoCos[10]" are defined as contractually agreed (Zhou *et al.*, 2012) debt-to-equity[11] convertibles. So, in this and the next chapter the differences of CoCos to other contingent capital proposals are that first, CoCos do not have the aforementioned principal write-down feature, but an irreversible conversion of debt into equity. Second, there are different trigger events. For example contingent capital can be triggered by a regulatory agency's decision. CoCos, as suggested in chapter 7, can have a market-based trigger. The first part of chapter 7 contains an empirical analysis of contingent capital notes that have a write-down feature, but are called "contingent convertibles" or "CoCos" by the issuing banks. So, strictly speaking there is no "conversion" of debt because it is simply a write-down, or complete write off, on these notes. So, it would more appropriate to call these notes "contingent write-down" or "contingent de-leverage" bonds.

Furthermore, the term "bail-in" circulates in the discussion about CoCos. For example, Perotti and Flannery (2011) stress that CoCos "represent a form of private bail-in cushion for individual bank distress" (p. 1). However the term "bail-in" is exclusively reserved for any regulatory measure that is exercised by a regulatory agency (Zhou *et al.*, 2012). Commentators of the banking crisis frequently emphasised the need to make shareholders and

[10] Alternative notations evolve in the nascent literature and are presented in the literature review below. For the sake of readability this chapter uses the most prominent one, contingent convertibles or just CoCos.
[11] Note that "equity" and "capital" are used interchangeably.

creditors of a bank pay for financial losses before a bail-out by the government with taxpayers' money is even considered. So, policy makers have high expecations of contignent capital (BCBS, 2011a; Haldane, 2010; Group of Governors and Heads of Supervision, 2010).

From a regulatory agency's point of view depositors are the most important group of creditors of the bank. They are of fundamental importance to the financial intermediation exercised by banks. A stable operation of the payment system constitutes a public good[12]. CoCos convert into a predetermined amount of equity upon an also predefined trigger event. Ideally, conversion immediately boosts the capital ratio of a bank to a healthy level to absorb financial losses and hence abates concerns about disintermediation, i.e. less lending due to mass withdrawals of deposits.

The analysis of CoCos from a macro-prudential perspective is divided into two main chapters. This chapter gives a literature review with a critical analysis of the proposed CoCo designs in the nascent literature. Consequently, CoCos are compared to the increased minimum capital requirements, which are the most important regulatory tools. This comparison reveals that CoCos can incentivise banks towards moderation in taking risks that equity alone cannot. The findings are crucial for the design of CoCos that is subject of chapter 7. There, the CoCo proposal helps fill the gaps in the literature. From a practitioner's point of view including regulators, bank managers, and CoCo investors, the proposed CoCo design enhances financial stability and offers a low-risk investment opportunity.

The purpose of this chapter is to give an introduction to the basics of CoCo before designing a CoCo proposal that qualifies it for being a macro-prudential tool. The latter is subject of chapter 7. The existing literature on CoCos deals with issues such as finding an appropriate pricing model. These papers raise valid research questions and certainly give crucial insight into the topic. However, their results are more interesting for theoretical argumentation within the quantitative string of the theory than for a practical application. One of the obvious concrete applications is to introduce CoCos in the recovery and resolution of struggling banks. For example, CoCos can be a tool of the BRRD of the SSM in the European macro-prudential regulatory framework, mentioned in sub-section 3.4.4.1 of chapter 3.

The methodology in this chapter differs for it analyses CoCos within a macro-prudential framework. Particular attention is paid to the incentive structure of different stakeholders of a

[12] One of the criteria of a public good is the non-exclusivity. This means that individuals cannot be excluded from benefitting from the public good. A text book example is traffic light that increases street safety also for those individuals that do not pay for the provision of such a public good. In order to curb this free rider problem the public authorities may collect taxes from each individual to finance public goods.

bank, such as the management, shareholders, depositors, and other creditors. The discussion about CoCos is compared to the established banking theory. Among them are for example the notions how leverage in general and deposits in particular should, according to the theory, increase market discipline. The bankruptcy of a bank can be costly but due to government guarantees to protect deposits and the payment system, banks suffer from moral hazard. Thus in the presence of such guarantees, which cannot credibly be revoked, the market discipline does not exercise full power.

This chapter's original contribution is that it analyses CoCos from a different theoretical angle than the majority of the literature. It emphasises that CoCos can disentangle the incentives of different stakeholders in a bank in order to address issues of moral hazard that come with a debt overhang problem and implicit and explicit government guarantees alike. In short, the debt overhang problem is a persistent problem when a bank is close to bankruptcy but its shareholders are reluctant to inject further equity that can rescue the bank. The debt overhang is addressed in more detail in sub-section 7.3.4 of the next chapter, where an alternative CoCo design proposes how to circumvent the debt overhang problem.

Section 6.2 recapitulates the current regulatory treatment of contingent capital in general according to Basel III. Section 6.3 gives a literature review of CoCos. The chronological order of key papers furthermore sketch how the discussion evolved from early ideas to more comprehensive formal models. Section 6.4 compares CoCos to higher capital requirements, i.e. a higher equity ratio, that are the most prominent and important tool at the regulatory agencies' disposal. So far this thesis deliberately saved a theoretical discussion of bank runs, the disciplining powers of deposits and government protection schemes, and leverage for the discussion of CoCos. Section 6.5 concludes and answers the research questions.

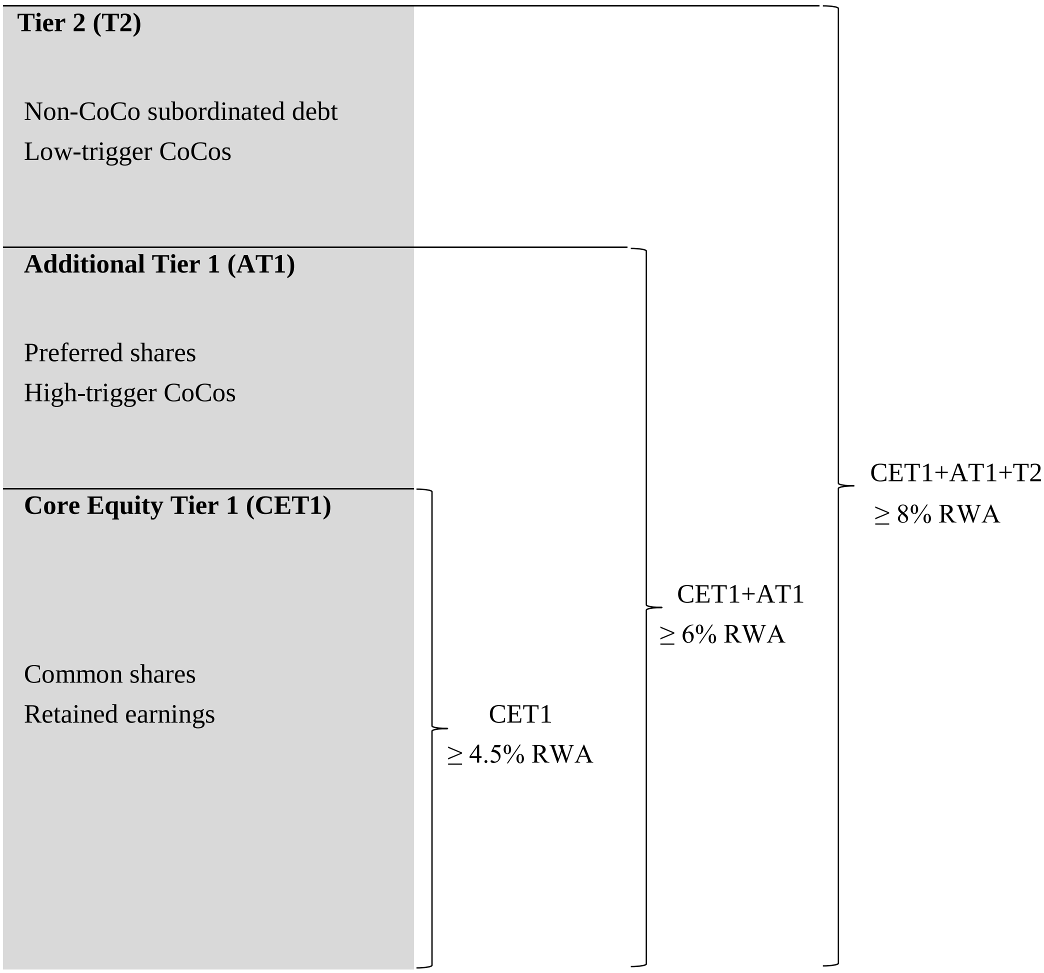
6.2 Regulatory treatment of contingent capital under Basel III

This section shows the regulatory treatment of contingent capital in the Basel II framework. In general terms, the Basel II minimum capital requirements from 2004 distinguish between three tiers of capital. First Tier 1 is "hard" or core capital that is ready to immediately absorb financial losses and retained earnings in the form of not-distributed dividends to shareholders. Tier 1 capital consists of common equity that absorbs losses on a going-concern basis, meaning that the bank is not faced by a bankruptcy but is expected to survive current financial distress.

Second, Tier 2 capital, or supplementary capital, include hybrid debt instruments. In addition to common equity the revised capital accord Basel III leave space for non-common equity instruments that fulfil certain criteria. Third, Tier 3 capital is short term debt with a nominal maturity up to two years and neither any interest on such a debt nor the principal value is payable if the bank is below its minimum capital requirement, or payment of these would drive the capital below this requirement. The sum of all tiers accumulates to a minimum of 8 per cent. Furthermore certain ratios between the tiers are in place. Tier 2 must not exceed Tier 1 capital.

In a revised version from 2011 the new capital accord, Basel III, forwards a more stringent definition of capital. Table 6.1 below gives a simplified illustration according to Avdjiev *et al*. (2013). The minimum capital ratio is still set to 8 per cent. Tier 1 consists of "core" equity including common shares, retained earnings, and reserves from the re-evaluation of assets. Additional equity comes from preferred shares and high-trigger CoCos. Tier 2 capital consists of subordinated debt and low-trigger CoCos. Tier 3 is discarded. A complete list of the definitions can be obtained from the BIS (2011).

Table 6.1: CoCos in Basel III capital requirements. Source: Avdjiev *et al*. (2013).



High-trigger and low-trigger CoCos refer to different purposes of the respective CoCos and hence are differently recognised by capital regulations. As the name suggests a high-trigger CoCo is converted before a low-trigger CoCo, i.e. on a going-concern basis and gone-concern basis, respectively. Items that classify as Tier 1 capital are loss-absorbing and allow for a continuation of the bank's business, the bank stays a going-concern.

Basel III in general allows for CoCos few policy makers explore this regulatory tool. For example policy makers in the USA do not foster CoCos. On the other hand, the Swiss Financial Market Supervisory Authority (FINMA) (2011) already introduced high and low-trigger CoCos for their banks. One explanation can be fundamental differences in the treatment of hybrid securities, as indicated in domestic tax laws. In the USA the debt component is emphasised while in other countries, such as Germany, hybrid securities can enjoy a preferred tax treatment.

At the point of the bank's non-viability, i.e. a foreseeable bankruptcy, Basel III stipulates that all non-common equity instruments of Tier 1 and Tier 2 must be fully loss-absorbing. Only after all capital resources are exhausted, capital injections by the public can be considered. In addition to reinforcing that all available private capital is used before public aid is considered, a new option for a gone-concern bank is to bail-in other creditors. One of the highest-ranking items on the agenda of regulatory reform is making banks' creditors pay before authorities bail out banks with taxpayers' money. This is also the predominant feature of CoCos.

In addition, further restrictions on those creditors who have regular debt claims could be imposed. One of them is to write down their claim temporarily or permanently given that the bank is in severe distress that could cause systemic risk. Alternatively, their debt claim can be converted into equity. Both alternatives are due to the discretion of a regulatory agency. The crucial difference between these measures and CoCos, as discussed in this chapter, is that that the former are bail-in instruments and the latter are pre-defined contractual agreements. Put differently, while both ideas look identical at first glance, bail-in measures are decided and executed by a regulatory agency, CoCos feature an automated mechanism that does not leave space for discretion.

This is not a small difference. One of the driving factors behind systemic crises is uncertainty. Especially when it comes to making decisions about bailing-in banks' creditors, the discretion of the agency can quickly put creditors into uncertainty. If they see that creditors of another bank are bailed-in by the regulatory agency why should that not happen to them too? Hence, it would be rational to fire-sell these bonds, which again is perceived as a negative sign by the financial markets.

To conclude, at worst, contingent capital can have destabilising effects during a crisis if the point of non-viability of a bank is determined by a regulatory agency. At best, contingent capital can contribute to financial stability if the "contingency" is clearly defined. Basel III only allows for CoCos as AT1 and not Tier 1 core capital. Tier 1 capital is per definition available at all times. Obviously, only upon the contingency event, CoCos make available new equity or de-leverage by means of a write-off of the CoCos' nominal value.

This chapter defines CoCos as contractual agreements for a conversion of debt into equity upon a trigger event. The remainder of this chapter looks into the technical aspects of a CoCo design. The key conclusions are that for the proper functioning of contingent capital in general, much depends on who decides on conversion – contractually agreed CoCos or bail-in capital decided by a regulatory agency – and what the terms of conversion are.

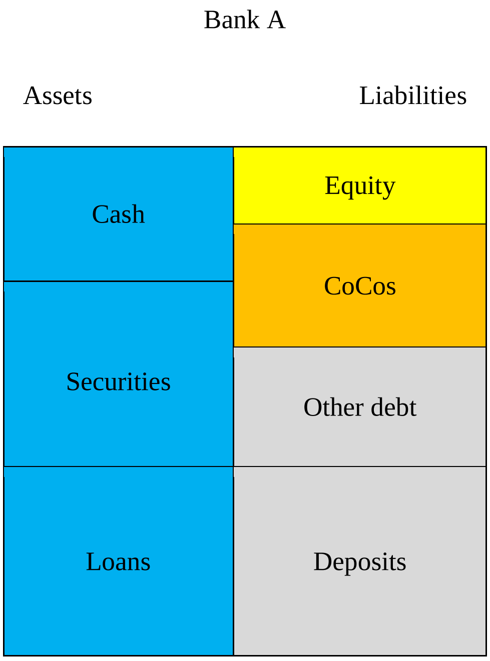
The next chapter outlines a CoCo proposal that serves as a script to go through a financially distressed bank. At all times it must be clear to bank managers, shareholders, and other stakeholders what is going to happen if the bank is dangerously undercapitalised. Only with this certainty these groups are able to make decisions. In contrast to the CoCo-related literature the macro-prudential research framework of this PhD thesis provides additional benefits to the CoCo design process. This means that by analysing the literature this chapter derives "essential features" a CoCo proposal must fulfil. One of the essential features is first and foremost to incentivise bank managers to exercise moderation in their business. And even if a systemic crisis arises CoCos can curb some of the losses compared to a state without CoCos.

6.3 Literature review on contingent capital

Regulators have high expectations for contingent capital in the regulation of banks, especially systemically significant institutions. The nomenclature in the still nascent body of literature varies. With "contingent capital" as the most basic name (McDonald, 2011) Flannery (2009) suggests "contingent capital certificates". Albul *et al*. (2010) call them simply "contingent convertible bonds". Other authors, such as Duffie (2009), are more specific in their proposals and call them "distress-contingent convertible debt". For the sake of readability the term CoCo is used.

However, the main purpose of such a hybrid instrument is to boost the capital ratio of a bank if a specific trigger event is hit. For example, as soon as a bank's capital ratio falls below a previously defined ratio, a transformation of the debt-like CoCo into equity is triggered (BCBS, 2010a). The debt claim of the CoCo disappears and CoCo investors are repaid in newly issued equity of the bank. Table 6.2 below illustrates CoCos on a bank's balance sheet.

Table 6.2: A bank's balance sheet with CoCos. Source: Own illustration.



The asset side is constructed following a liquidity hierarchy, from the most liquid asset cash over securities to the least liquid assets, i.e. loans. The liability side is constructed according to loss absorbing capacity. Equity, or also called capital, is the first tranche to mitigate financial losses stemming from the asset side. Asset write-downs are a consequence of the impairment of the current value of the asset side. CoCos follow and are converted into equity before other debt would be considered to be subject of regulatory mandated write-downs. Deposits are the last tranche. Note that the relative sizes of the boxes do not indicate specific ratios but are solely for an illustrative purpose. As soon as the trigger event occurs, the CoCos are change from being a debt claim into a residual claim on the profits of the bank, i.e. equity.

One view of the crisis is that there was a lack of discipline among banks to abstain from unsustainable leverage, loading on unsustainable risks, and a lack of monitoring efforts by their stakeholders. Stakeholders are the sum of economic agents that have an interest in the soundness of a bank. These include shareholders and debtholders, including depositors.

Figure 6.1: Design features of contingent capital. Source: Own illustration based on Avdjiev et al. (2013).

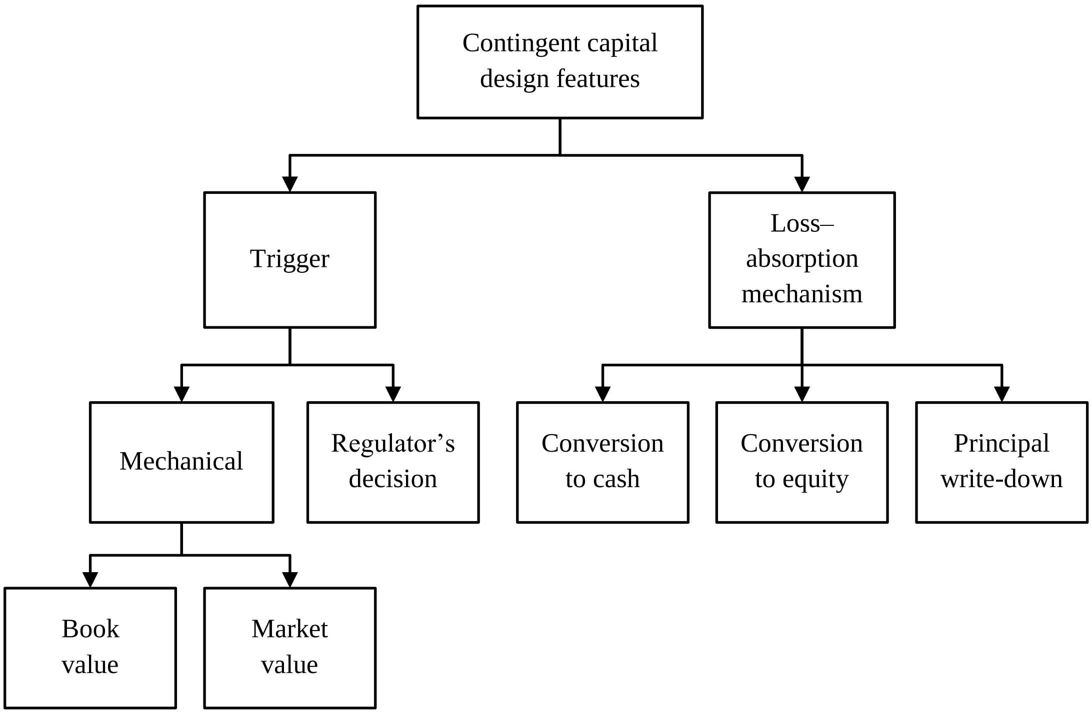


Figure 6.1 shows the different design features for contingent capital. The trigger event can be mechanical or conversion can be exercised by a regulator's decision. In the case of a mechanical trigger– which is assumed in the next chapter – the convertible is referred to as CoCo; in the case of a regulatory announcement of a conversion the contingent capital is classified as bail-in capital. Since CoCos are triggered to counter a weak capital cushion of a bank a drop of capital ratio is the trigger event. This mechanical trigger must further be specified as either a book value of capital or market-based evaluation of the equity.

The loss-absorption helps boost the capital ratio, i.e. de-lever a bank. Investors of contingent capital can be compensated for a loss of their debt claim either with cash, obtain newly issued equity, or see their debt claim mandatorily written-down. The next sections look closer at the differences between the choices of the trigger event and the terms of conversion.

6.3.1 Bail-in capital vs. contractually agreed contingent capital

This sub-section demonstrates the advantages of a contractually agreed CoCo conversion over a difficult to anticipate regulatory decision to trigger the "contingency".

Calello and Ervin (2010) give an example of a debt-to-equity swap by a regulatory agency's decision – so it is a bail-in according to the definitions given in the introdution. This could have been an alternative solution to the collapse of Lehman Brothers:

- The first step would have been to write down the assets of Lehman Brothers by US$ 25 billion which would have wiped out shareholders completely.
- Second, subordinated-debt holders and senior unsecured debt holders would recapitalize the bank. The first investor group would have converted US$ 25 billion in exchange for 50 per cent of the new equity of the bank. The second group would receive the other 50 per cent of the equity by converting 15 per cent of their US$ 120 billion total claims.
- On the balance sheet, the new equity would be worth US$ 43 billion, approximately double the size of Lehman's previous capital base. The management would have been replaced by the new owners. The whole process could have been accompanied by a consortium of other big banks to make available a further funding facility for Lehman Brothers to eliminate the last remaining doubts of the markets about the survival of the firm.

Calello and Ervin (2010) underline the advantage of regulatory authorities' bail-in provisions for "[i]t would give officials the authority to force banks to recapitalise from *within*" (emphasis added). The authors do admit, however, that this whole process must be executed in a short time period to soothe markets before they panic. They compare the case of the "fast-track" reorganization of CIT, a small-business lender, to the case of Lehman Brothers. The former was considered fast within 38 days, but the latter just allowed for 48 hours before a panic would eventually spread.

Bail-in capital includes a decision-making process that requires time. But saving time is a crucial factor in curbing a panic that could cause and exacerbate a systemic crisis in the worst case. CoCos are contractual agreements that map out the course of action once the contingency occurs. Therefore CoCos, compared to bail-in capital, are a time-saving measure to recapitalise the bank from within.

The authors further conclude that a remaining problem is that "[s]ceptical customers and counterparties would still need to be convinced to deal with the new company" (Calello and Ervin, 2010). Another example that illustrates the concerns raised so far is the expropriation of its shareholders when Northern Rock was brought into public ownership. Due to the nationalisation of the bank, Northern Rock's shareholders faced severe losses. The primary duty of the authorities was not the protection of private property but "comparing the financial benefits to the taxpayer of nationalisation with the alternatives available" (SRM Global

Master Fund LP, 2009, para. 166). Similarly, in order to protect taxpayers against losses, some jurisdictions rule that "funding provided to an entity that is being restructured or resolved in other ways enjoys a priority over other creditors" (BCBS, 2011b, p. 22). In more general terms, a bank's existing shareholders' position could still be diluted in the future even after the institution has been saved. Consequently, shareholders and other investors would be at odds with each other, costing the bank precious time to quickly recapitalize. However, a private solution is always preferable to a publicly funded government intervention. With a government institution, which acts on behalf of taxpayers, it is not clear whether existing shareholders would be compensated at all in the case that a bank is a going-concern, i.e. surviving financial distress.

Of course, shareholders of gone-concern banks lose wealth. So do bail-in capital investors in either case whether the trigger event stipulates conversion to equity or a principal write-down. If the bank is under severe financial distress but still with the prospect of remaining a going-concern, a prediction about the net loss of wealth cannot be done with precision. A bail-in exclusively serves the regulatory objective of maintaining financial stability by giving the regulatory agency room for manoeuvre. This discretion comes to the detriment of bail-in capital investors who cannot predict their future wealth.

To draw an interim conclusion, CoCos give two advantages over bail-in capital. First, due to a contractual agreement on the contingency event, i.e. the trigger, conversion occurs immediately with no delay that could otherwise cause uncertainty to the involved parties. Second, due to a contractual agreement on the terms of conversion into equity CoCo investors are better able to estimate their wealth compared to a situation in which their wealth depends on the decisions of the regulatory agency.

These two examples provide the string of argumentation for the remainder of this chapter and the CoCo proposal in chapter 7. The incentives of, bank managers, shareholders, CoCo holders, other creditors, and supervisors, have to be aligned towards the new objective of a macro-prudential regulatory framework: promoting financial stability.

6.3.2 The origins of contingent capital

Contingent capital as a tool of increasing financial stability found attention during the 2008 Crisis when a group of fifteen leading economic scholars, known as the Squam Lake Group (2009), gathered and reasoned about the basic features contingent convertible bonds must provide in order to fulfil this aim. The idea of this kind of hybrid debt is not completely new and can be traced back to the contributions by Doherty and Harrington (1997) and Flannery (2002). Hosted by the Council on Foreign Relations, the Squam Lake Group consisted of fifteen academics first convened in fall 2008. Of the original fifteen members Duffy (2010) and Kashyap together with Rajan and Stein (Kashyap *et al.*, 2008) are now among the most important authors.

The Group suggested that the trigger event for the conversion of "regulatory hybrid securities" – a generic term before the name contingent convertible bonds, or CoCos, was introduced – should depend on two criteria: First, the conversion is only possible when the regulators announce that there is a systemically relevant crisis that may affect the whole banking sector. Second, after a declaration is made, a bank must fulfil a specific requirement, the trigger, that finally leads to the conversion. The first criterion would help to maintain the disciplining power of debt financing on the bank's management.

The second criterion helps avoid an undiscriminating obligation to convert among the banking sector. Otherwise banks that suffer from financial stress and should be allowed to fail would be strengthened by a conversion. Healthy banks would be punished by unnecessarily increasing their equity ratio.

This two-component trigger would avoid an indiscriminate conversion of debt into equity across the banking industry which would penalize those banks that have taken due care in reinforcing their capital ratio and putting adequate risk management measures in place. In the long run, banks would have little incentive to independently reinforce financial resilience. The BCBS adopted this proposal and further suggest that the trigger "could be based on any combination of regulatory ratios, market based ratios, accounting ratios, bank discretion, supervisory discretion, and more." (BCBS, 2011a, p. 26). Obviously, this suggestion is reminiscent of the new intrusive approach to macro-prudential regulation since it involves the regulator's decision.

However, the idea to have banks use hybrid securities to counter financial distress dates back to pre-2008 crisis times, see Flannery (2002).[13] The aims of CoCos are the protection of depositors and taxpayers, and the internalization of costs of bankruptcy risk by shareholders. Automatic re-capitalization is an essential design feature. The trigger event is a pre-defined ratio of the market value of equity and the notes convert into common equity. After

[13] In his contribution Flannery analyses the potential for "reverse convertible debentures" (RCDs). For the sake of readability the term CoCo is used.

conversion of outstanding CoCos, the bank is required to promptly replace the converted bonds with a new issuance of such bonds.

The simple model over two periods t = 0 and t = 1 works as follows, see Table 6.3 below: A bank is equipped with assets worth \$100, liabilities are composed of \$8 equity distributed among N = 10 shares, \$5 CoCos, and \$87 deposits.

Table 6.3: Numerical example for CoCo conversion into equity. Source: Flannery (2002).

t = 0		t = ½		t = 1	
Assets	Liabilities	Assets	Liabilities	Assets	Liabilities
100	8 Equity	97	5 Equity	97	7.76 Equity
	5 CoCo		5 CoCo		2.24 CoCo
	87 Deposits		87 Deposits		87 Deposits
N = 10,		N = 10,		N = 15.52,	
$P_S = \frac{\$8}{10} = \$0.80$		$P_S = \frac{\$5}{10} = \$0.50$		$P_S = \frac{\$7.76}{15.52} = \$0.50$	

In t = 0 the bank has a capital ratio of 8 per cent. The bank has N = 10 shares. Hence the share price P_S of the equity is \$0.80. Any value below this is set as the conversion trigger. Of the total outstanding \$5 CoCos only a portion is converted in order to increase the capital cushion back to a 8 per cent ratio. Now, assume that a shock leads to a value decline in assets of \$3 that is reflected in a write-down of equity from \$8 to \$5. Before the final balance sheet is achieved in t= 1, the decrease in the capital cushion and ratio is shown in t = 1/2, the transition from period 1 to 2. The ratio is now (5/97) = 0.05154,(5.15 per cent). Equity is now re-evaluated and priced at (\$5/10) = \$0.50. However, in order to maintain the regulatory minimum of 8 per cent, equity must be \$7.76 since (x/97) = 0.08 <=> x=7.76. The difference of \$2.76 is compensated by converting \$2.76 worth CoCos. Priced at a fair per share price of P_S = \$0.50, this results in issuing (\$2.76/\$0.50) = 5.52 new shares for CoCo holders, who face no financial loss because of this conversion at par. Flannery points out that the outstanding CoCos should be issued in different tranches to make it easier to anticipate the order of conversion.

Following up his 2002 paper, Flannery (2009) furthermore specifies the advantages of

CoCos.[14] When conversion occurs, the debt-for-equity swap reshuffles the capital structure of the bank but the asset side and assets value of the bank stays identical just in time of conversion. Hence, the default probability and loss given default decline, making the bank more robust. Wiping out previous shareholders is one key feature to reinforce market discipline.

Further holding restrictions must be imposed on other systemically important institutions. They must not own CoCos especially of other systemically important firms to avoid a situation where financial losses due to conversion could lead to contagion. The yield on observable CoCo prices can provide additional market information about a bank's capital adequacy. In contrast to his initial conversion rule to recapitalize equity to the chosen regulatory capital minimum of exactly 8 per cent, Flannery (2009) suggests converting outstanding CoCos to 1 per cent point above the required minimum. Consequently conversion would happen on a less frequent basis.

6.3.3 Design problems of CoCos: Endogeniety and prohibitive pricing difficulties

This sub-section discusses the most pressing problems with CoCos that could defeat their purpose. Kashyap *et al*. (2008) discuss the issue of endogeneity of the trigger. For example there could be "problems with indeterminacy or multiple equilibria" (p.33) if the trigger is based on the bank's stock prices and a stock price index of other banks as a benchmark. The conversion of CoCos indeed serves as insurance for a bank's capital and should be reflected in its stock price. Consequently, the trigger event should be an exogenous measure. They advocate allowing a conversion only when the financial system is severely in distress, indicated by a high volume of aggregated losses among the banking industry. In contrast to CoCo proposals such as Flannery's (2002) they put a high weight on the disadvantage that come with conversion. The bank would be provided with "debt forgiveness if it performs poorly enough [and] it could exacerbate problems of governance and moral hazard" (Kashyap *et al*., 2008, p. 35f).

Sundaresan and Wang (2010) present an in-depth analysis of the most worrying technical aspect of a CoCo design: The threat of multiple price equilibria. The reason for an absence of an equilibrium lays in the very purpose of CoCos. Additional capital is triggered when economic agents "are not allowed to choose a conversion policy in their best interest" (p. 4).

[14] Flannery introduces the term Contingent Capital Certificates (CCCs). For the sake of readability the term CoCo is used.

One key result is that CoCo bond holders tend to prefer an equilibrium that is near early conversion and incumbent shareholders tend to choose an equilibrium that suggests a delay conversion or avoid it all together. Markets with multiple or no equilibria increase uncertainty.

Pennacchi *et al*. (2011) demonstrate the multiple equilibria concern of Sundaresan and Wang (2010) of CoCos with a simple numerical example. Suppose the following balance sheet of bank A in Table 6.4:

Table 6.4: Numerical example for a bank's balance sheet with CoCos. Source: Pennacchi *et al*. (2011).

Bank A

Assets	Liabilities
Assets $1100	Equity $70 (with N = 7 outstanding shares)
	CoCos $30
	Senior debt $1000

Assume that the value of assets stays constant. The CoCos have a trigger set at a share price of $8. With seven shares in circulation, the current share price is $10. Conversion of all CoCos is executed when the stock price is lower than the trigger, since conversion exactly at the trigger is unlikely to happen in reality, see McDonald (2011) above. The observable share price relevant at the time of conversion is for example $5 well below the trigger. Accordingly, markets assume that $30 worth CoCos at this conversion price delivers $\left(\frac{\$30}{\$5}\right) = 6$ new shares to CoCo holders. The new equity added to pre-conversion equity is now $100, hence fair value of equity over outstanding shares is $\left(\frac{\$100}{13}\right)$ = \$7.69. This represents the new unique equilibrium price, which is much lower than the pre-conversion equilibrium of \$10. CoCo holders have a net wealth increase of $\$7.69 \times 6 - \$30 = \$16.14$. This is a transfer of wealth at the expense of previous shareholders since their net wealth decreased by 23.1 per cent per share from \$10 to \$7.69. When share prices and CoCo prices are determined simultaneously, so Sundaresan and Wang (2010), incumbent shareholders prefer the first equilibrium and CoCo bond holders prefer the second, lower equilibrium price.

The threat of multiple equilibria is highest when the bank's value drops to a level close to the equity trigger. The possibility for this wealth transfer is the reason for the existence of the two possible equilibria prices \$10 or \$7.69. If investors believe conversion will not happen, equity will stay above the trigger. If investors believe that conversion will happen, equity value will hit the trigger in a self-fulfilling manner. In the long run, Sundaresan and Wang (2010) suggest that there can be a range of different equity values above the trigger.

There can be a special case of an absence of an equilibrium all together if conversion pushed the share price above the trigger. For example, suppose that in the numerical example the conversion price is not \$5 but approximates the trigger level from below, say \$7.50. Four new shares $\left(\frac{\$30}{\$7.50}\right)$ are issued to compensate CoCo holders. However, if share price recovers to its new fair value that with a total outstanding eleven shares now is $\left(\frac{\$100}{11}\right)$ = \$9.09, which is higher than the trigger of \$8. This results in a wealth transfer to shareholders. This leads to a paradox situation: If investors believe that conversion will happen, equity must fall below the trigger; with the expectation that equity will be worth more after conversion, equity will not decline in value in the first place, hence avoiding conversion. If on the other hand conversion is assumed not to happen, equity's expected value is less than after a theoretical conversion. Therefore equity is more likely to fall below the trigger, hence causing conversion.

Sundaresan and Wang (2010) determine that in order to avoid multiple equilibria or absence of an equilibrium price a "zero value transfer condition" (p. 7) is essential in any CoCo design. This translates into a conversion at par value to CoCo bond holders, so they are indifferent between the face value of unconverted CoCos or receiving shares with a market value that exactly equals this face value. This key feature is introduced to the CoCo proposal in the next chapter.

The competition between CoCo holders and incumbent shareholders ought to exercise discipline on the bank. However, the post-conversion wealth transfers between these groups introduce further problems. In particular, multiple equilibria pricing problems raise doubt whether CoCos are an actual improvement. Nevertheless a zero value transfer condition abates the problem. Rather than putting various groups into potentially harmful competition, designing CoCos so that at least one group is indifferent eliminates the pricing problem. So a conversion of CoCos still enhances the equity position of the bank without disruptive side effects. More realistically, observable equity prices in the markets will change over time. In fact, in the *exact moment* of conversion, the wealth of a CoCo investor is identical since price of the CoCo bond equals shares received at current market price. However, the equity is subject to re-evaluations in the financial markets anyways and so the wealth of the former CoCo investor is likely to increase or decrease and does not stay constant over time. This is a key argument for the CoCo design proposed in the next chapter.

6.3.4 The dual trigger: Determination of conversion subject to micro- and macro-level

This sub-section identifies the trade-offs between the terms of conversion of CoCos into equity and uses numerical examples based on McDonald (2011) in order to show how conversion affects investors' wealth. McDonald (2011) suggests a dual price trigger that comprises of a micro-level and macro-level trigger. The conversion of CoCos is triggered when both the bank's stock price and a stock index fall below a certain average value during a particular time window. This dual price trigger is the synthesis of the proposal to expose the contingent capital conversion to a systemic crisis originally envisioned by the Squam Lake Group[15] and a trigger that is entirely based on microeconomic indicators such as a bank's stock price.

In a simple numeric example, he compares different design features of a CoCo. Conversion is triggered if, and only if, the bank's share price falls below a set "stock trigger", say \$50, and if the "index trigger", that serves as a benchmark for a system-wide fall in value preceding a financial crisis, falls to below \$90. Furthermore, CoCo contracts can be written with different conversion mechanisms (see, McDonald, 2011) as listed in Table 6.5 below.

[15] The Squam Lake Group suggests leaving the declaration of a systemic crisis to a regulatory agency based on macro-economic indicators. Consequently in regards to the terminology used in this chapter the Group's proposal is a "bail-in" capital proposal.

Table 6.5: List of different CoCo terms of conversions. Source: McDonald (2011).

• Fixed share conversion	CoCo holders receive a certain number of shares for every CoCo bond they hold
• Fixed dollar conversion:	CoCo holders receive shares each worth a predefined dollar value
• Par conversion:	The received shares are worth the par value of the CoCo bond, \$1000 CoCo bond converts into \$1000 shares
• Premium conversion: (from CoCo holders perspective)	The received shares are worth less than the par value of the bond, \$1000 CoCo bond converts into \$900 shares
• Discount conversion: (from CoCo holders perspective)	The received shares are worth more than the par value of the bond, \$1000 CoCo bond convert into \$1100 shares

However, McDonald notes that especially for the stock trigger, it is unlikely that the stock price will exactly touch the trigger lever before conversion. If the conversion allows for a little delay, perhaps the conversion will be executed at the end of the trading day, the stock price can still fall to \$48.

Under a fixed share conversion regime CoCo bond holders would convert their bonds into a fixed number of shares valued at the current stock price, which for 20 shares equals a conversion into equity worth 20 × \$48 = \$960. If the CoCo bond's value was \$1000, conversion comes with a loss of \$40. Anticipating this loss, CoCo bonds would have to pay a higher interest rate, i.e. coupon, given that the conversion price is unlikely to exactly equal the trigger price. In the example here, conversion at the exact stock trigger of \$50 rarely happens. In addition, when conversion is executed at a market price below the trigger, CoCo bond holders buy the new equity at a premium. If the CoCo bond contract stipulates a conversion into less shares, say 18, CoCo bond holders would buy equity with an implicit share price of $\left(\frac{\$1000}{18}\right)$ = \$55.556, which is higher than the stock price trigger.

Under ideal circumstances a fixed dollar conversion at par would not come at a loss for CoCo bond holders. Again, the actual stock price is \$48 and below the intended trigger of \$50. A CoCo bond worth \$1000 now is divided by the current share price of \$48 and compensates CoCo bond holders with 20.833 shares to preserve wealth of \$1000. Manipulation of the stock index pays off more if the bank's stock price can be decreased from \$51 down to well below the trigger. If the current price per share is pushed down to \$47 every CoCo bond would receive $\left(\frac{\$1000}{\$47}\right)$ = 21.277 shares. If the bank's share prices recovers to its initial level this strategy pays off 21.277 × \$51 = \$1085.127.

Alternatively, if conversion is not at par but is merely on a fixed share basis, manipulation becomes a concern. Suppose that the stock trades at \$52 just above the stock trigger and the index trigger is hit. If a trader owns a \$1000 CoCo bond and has the opportunity to short the bank's stock price to \$49, she would receive 20 shares at \$49 worth \$980 in sum. However, the short-selling strategy is not finished yet. If the infinitesimal decrease of the stock price just under the trigger is not a genuine signal that the bank's situation according to its fundamentals is deteriorating, the trader can anticipate that the stock price will go back to its initial level of \$51. Now her stocks are worth 20 × \$51 = \$1020 making a profit of 2 per cent. To counter this simple approach to manipulation is the introduction of "a wedge between the par value of the bond and the conversion value of the shares" (McDonald, 2011, p. 11). Conversion at par value suggests issuing 20 shares. The payoff for manipulation can be drastically decreased if the number of shares that can be received is decreased. If only 19 shares are issued but at a fixed price of \$50, the trader who holds the CoCo bond receives 19 × \$50 = \$950. This translates into a per share loss of $\left(\frac{\$50}{19}\right)$ = \$2.63. In order to make manipulation profitable, the bank's stock would have to recover to a value of at least \$52.36.

This leads to the conclusion that paradoxically, the more a conversion occurs at a premium, i.e. an immediate loss of wealth of the CoCo bond holder, the more incentive the CoCo bond holder would have to drive stock prices up after conversion. Under the proposed dual-trigger framework, manipulating a bank's stock price up when the market environment is already in distress – not yet in a crisis – seems unlikely. Manipulation of the market index is not a concern if the trigger is object to a 20-day average of the index. Hence, short-selling strategies do not pay off and the criticism that CoCos are prone to manipulations is dismissed.

McDonald's suggestion carries the advantage that the regulators are not involved in the conversion and the resulting credibility of market-based trigger allows an easier pricing of CoCos. The second advantage is that in the absence of a systemic crisis, an individual bank is still allowed to fail without having its CoCos triggered and a second chance of avoiding a bankruptcy.

However, he points out that his suggestion bears some contradictions when too-big-to-fail banks are involved. In expectation that there is no systemic crisis, the markets expect CoCos not to convert and would price them accordingly. Per definition, systemically important financial institution are big enough so that a decline in their individual trigger correlates with a decline in the relevant market trigger (index trigger), effectively defeating the purpose of a dual-trigger mechanism. However, "[i]f the contingent capital were expected to convert and prevent failure, the index would never fall below the trigger value and thus the contingent capital would not convert. If the contingent capital were expected not to convert, the index would fall below the trigger value and the [contingent] capital would convert" (McDonald, 2011, p. 6, footnote 9), hence another equilibrium price is the correct one. McDonald emphasizes that CoCos can serve as a backstop for regulatory failures and does not substitute good supervision.

6.4 The alternative to contingent capital: Why not simply higher capital requirements?

Despite the attention contingent capital and debt-to-equity CoCos have received in the aftermath of the financial crisis, a more basic question has to be answered. Why should CoCos be introduced and not just capital minimum for banks increasing in order to make banks more stable? A lesson learned from the global financial crisis of 2008 is that time was a scarce resource. Decision makers had been compelled to undertake incomprehensive actions or in the other extreme, delayed much needed action. For example, requiring banks to increase their capital cushion came much too late. It was only after the crisis when the U.S. American legislature took the necessary steps to mandate their banks to hold substantially higher capital ratios. Their European peers lack behind in implementing equal requirements. Of course, one might rightly suspect whether the administrative infrastructure behind deriving concrete decisions plays a role. The chain of consultation, discussion, and legal powers are explained in chapter 3 and do not need to be repeated here.

One important result for this chapter on CoCos is that timing is a crucial factor in mitigating a systemic crisis. The paradigm shift towards macro-prudential regulation should be accompanied with a higher sensitivity for countercyclicality. If all banks would be required by the regulating authorities to increase their capital in times of financial stress across the industry, then the single bank would see itself in competition with its peers for capital when capital is already expensive to collect because markets price-in the distress.

6.4.1 Optimal capital structure

This sub-section reviews the differnet theories on the choice of an optimal capital structure of a firm in general. The literature on the optimal ratio of equity capital to other liabilities has gained interest after the 2008 crisis. The Modigliani-Miller theorem of the irrelevance of a firm's capital structure is the foundation for corporate finance research. Modigliani and Miller (1958 and 1963) derive that in the absence of distortions such as different tax treatment of debt and equity, transaction costs, bankruptcy costs, and imperfect capital markets where individuals and firms cannot borrow at the same rate, total financing costs will not change. The riskiness of a corporation solely depends on its projected cash flow and not on the distribution of the proceeds to shareholders in the form of dividends and other creditors in the form of interest payments. Further studies, for example by Weichenrieder and Klautke (2008) relax these assumptions and examine the impact of taxes on financial structure. They conclude a significant incentive to increase a higher debt to asset ratio. As for bankruptcy costs, Altman (1984) estimated the costs to investors to about 20 per cent based on evidence from 19 industrial firms from 1970 to 1978. More precisely, this cost split up into a pecuniary loss of asset value, costs for the liquidation of the firm, and legal expenses.

Weichenrieder and Klautke (2008) offer three additional theories about an optimal capital structure decision of a firm. The trade-off theory assumes a deviation from Modigliani and Miller's zero bankruptcy costs. A high leverage increases the probability of bankruptcy since less equity is available to be written down if assets lose value. The firm can internalize some of the bankruptcy costs – decreasing the probability of bankruptcy – by trading off loss-absorbing equity at a loss of tax deductibility of debt, a loss of the so called "tax shield". Jensen (1986) derives the advantage of debt to decrease agency costs in general terms; an application for banking can be found in Kashyap *et al*. (2008).

Second, the free-cash-flow hypothesis suggests that a high debt-to-equity ratio, i.e. leverage, disciplines a firm's management. If relatively more debt has to be paid in the form of interest, then the management has fewer opportunities to pursue their own interest if it is not in the interest of the firm's owners. For example, in the absence of sufficient monitoring by the firm's shareholders, the management can extract cash or invest it according to their personal interest.

The third theory is the pecking-order hypothesis (Myers and Majluf, 1984). A firm is assumed to act in the interest of its shareholders despite information asymmetries to the advantage of the management. If the market valuation of the firm is higher than the private information of the management suggests, issuing new equity increases shareholder value. However, markets are aware of the information asymmetry and interpret the issuance of new shares as a negative signal; the firm is deemed overvalued. As a result, share prices decrease and shareholder value, too. Therefore, the management is reluctant to expose shareholders to the severe valuation problem of equity under asymmetric information. Equity is the lowest in the pecking order of financing the firm. Internal financing opportunities, such as retaining earnings, are the first choice. Only if external debt-financing is exhausted, raising equity would be considered. Dierkens (1991), D'Mello and Ferris (2000), Eckbo (1996), and Shyam-Sunder (1991) find empirical evidence in support of this theory.

6.4.2 The costs of equity in banking

In preparation for the specific CoCo proposal in the next chapter, this sub-section analyses a bank's stakeholders' incentives. These incentives are reflected in the costs of the choice of an equity level. Bank managers, shareholders, CoCo investors, and regulators pursue different goals. The latter are concerned with the financial stability of the system that may be threatened by an individual bank, the bank management is not directly concerned with this. However, it is also the aim of this and the following section to demonstrate how setting incentives can be imbedded into the new approach to macro-prudential regulation. A frequent comment in banking is that equity is costlier than debt finance. Also, banks provide a public good by taking in deposits and therefore must be recognized differently in comparison to other industries. Diamond and Dybvig (1983) developed a basic model for deposit-taking banks (see also Diamond and Rajan, 1999). Banks function as financial intermediaries with special endowments. They are better skilled than other economic agents to collect interest payments from their borrowers. A bank can give a long-term maturity credit to an entrepreneur by financing it with a flow of deposits of shorter maturities. It is not necessary that one or several particular depositors lend against the particular credit to the entrepreneur to make the loan liquid. Instead the only important requirement to make and keep the credit liquid is that at all times enough deposits are placed with the bank.

If a bank has a high level of equity, meaning fewer deposits relative to equity, the bank could survive longer if a run on uninsured deposits occurs. Hence, the bank could negotiate down the payments of interests on deposits and retain more revenues to their own interest. With more deposits on the balance sheet, i.e. lower capital ratio, this incentive to threaten depositors is lowered. One of the key conclusions is that banks are exposed to a collective action problem among depositors. Because there is a latent threat of depositors starting a run on the bank whenever they think their deposits are in danger, bankers would commit to make decisions towards the survival of the bank. Thus, importantly, Diamond and Rajan (1999) stress that a degree of "financial fragility is essential for banks to create liquidity" (p. 7).

The creation of liquidity refers to the flow of credit in the economy. In contrast to the pecking-order hypothesis according to Myers and Majluf (1984) because of asymmetric information, Diamond and Rajan (1999) see the costs of high equity in a social loss of liquidity creation.

However, Admati *et al*. (2013) challenge the dogmatic view on the high costs of equity to banks. According to critics of higher capital minima, too high an equity capital ratio could in fact harm the efficiency of the banking industry as presented in Diamond and Rajan (1999), and would decrease lending to the real economy, thus stripping economic growth. Admati *et al*. (2013) argue that answering the question whether equity is costly for banks falls short of considering different costs and benefits that have to be traded off. This argument finds favour with regulatory authorities like the ECB (Nouy, 2015). In more detail, the discussion has to differentiate between social benefits, social costs, private benefits, and private costs of higher equity ratios. The opacity of certain assets like loan portfolios gives reason to doubt this argument. Managers can exploit their information advantage together with the high liquidity to reshuffle their asset positions quickly without notice of the creditors. This information asymmetry and agency problem is a further distortion excluded in the Modigliani-Miller theorem, but is nevertheless highly relevant in reality.

Miles *et al*. (2011) calculate the social optimal level of capital. UK banks should hold capital of 16 per cent to 20 per cent. This significantly exceeds current demands by the regulators. The intended result is to offset the additional private costs of banks that come with holding more equity with the social benefit of having a banking sector that is better prepared for extreme shocks. Kashyap *et al*. (2010) come to a similar result for U.S. banks but warn that changing regulations just towards increasing the minimum capital ratios would lead to regulatory arbitrage. More specifically, they are concerned that a new "capital regime, even if it does not materially impact the cost of credit, raises very significant concerns relating to the reshaping how credit will be provided, and the associated implications for financial stability" (p. 32).

From the policy makers' side, the UK Parliamentary Commission on Banking Standards issued the "Changing banking for good" report and conclude that:

> "If higher capital requirements make banks less vulnerable to disasters in the future, those banks are a more attractive investment. Further reforms will carry a cost in the short term, but an effectively-reformed banking sector subject to less uncertainty will be a better long-term recipient of investment" (Commission on Banking Standards, 2013, para. 39, p. 21).

By the same token, the Commission on Banking Standards acknowledge that the initial position in respect to tax law for banks' choice of financing was tilted towards (over-) leverage. The following is an extract from written and oral evidence to Parliamentary hearing, summarized in the annex to the Commission on Banking Standards report:

> "Ernst and Young highlighted [in written evidence] that the tax system was not 'aligned to incentivise similar behaviour to regulation', meaning that complying with regulations could 'penalise banks from a tax perspective'. Andy Haldane argued [in oral evidence] that the tax system was pulling in the opposite direction to regulatory capital requirements, meaning that regulators were 'trying to induce banks to do something that the tax system at present provides a disincentive to do, which is to raise extra equity'" (Commission on Banking Standards, 2013b, para. 187, p. 159).

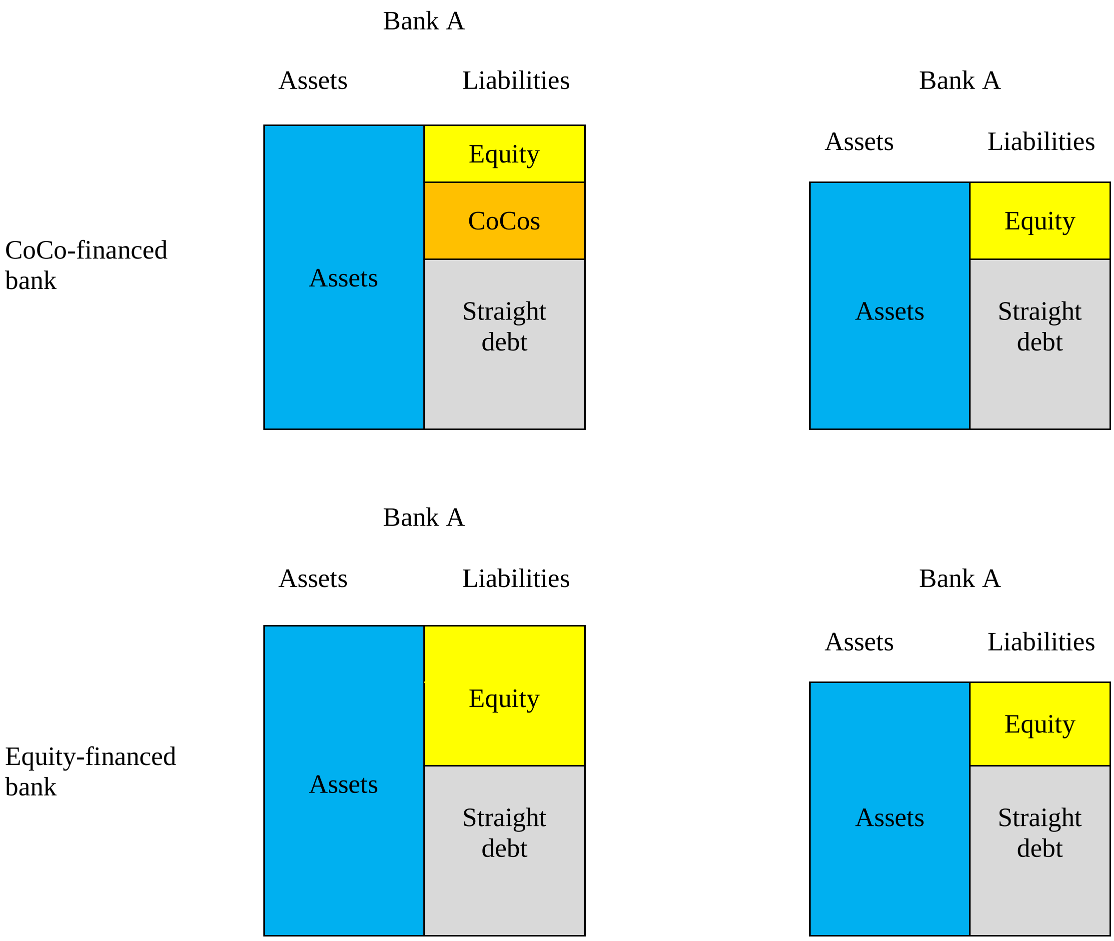
Admati *et al*. (2013) doubt the benefits of CoCos. Despite the possible advantages of having an automatic conversion mechanism in place, contingent capital holders might want to sell their securities well before conversion conditions are reached. The intended smoothing of distress would just be moved forward in time. However, this chapter argues that moving the frictions stemming from asymmetric information to an earlier stage well before systemic risk concerns arise should be the purpose of CoCos.

6.4.3 Equity ratios vs. CoCos: Different incentives for banks

This sub-section demonstrates that CoCos can manipulate bank managers' incentive towards prudence in a way that equity alone cannot. In their criticism of CoCos Admati *et al*. (2013)

focus exclusively on the loss absorbing properties of equity and CoCos illustrated in the following table.

Table 6.6: Bank equity cushion before and after CoCo conversion. Source: Admati *et al*. (2013).



The starting situation for a bank, according to Admati *et al*. (2013), with CoCos along equity and debt finance and a bank that is financed with equity and debt is pictured on the left-hand side of the above Table 6.6. Deposits fall into the category of "straight debt". Before the shock on the bank's balance sheet has to be written down, i.e. a loss in the value of assets like defaulting mortgages, the assets are assumed to be identical regardless of the bank's financing on the liabilities side.

The shock is reflected in the decline of asset value translates into a decline in equity to absorb the loss. In the upper left balance sheet the initial write down on equity is sufficiently large to fall below the contractual trigger of outstanding CoCos, the balance sheet results to a form pictured in the upper right-hand side. In a simple case, upon the trigger event all CoCos convert into a new equity issuance with the same face value. For example, if the CoCos have a value of $100 they will be replaced with new equity worth $100. Now the equity cushion is increased and available for absorbing further losses. The balance sheet on the upper right-hand side shows the financial situation of the bank after the asset price correction has been matched with writing down equity, both from existing equity and newly issued equity after CoCo conversion. Note that the surviving equity is not exclusively composed of former CoCo investors. It is a mix of incumbent, pre-conversion shareholders' investment and CoCo investors who just saw their CoCos transformed into a shareholding. However, theoretically, the surviving equity cushion can be composed of former CoCo investors entirely only if the trigger for conversion is a zero per cent equity cushion. In this extreme case the equity cushion would be entirely wiped out and the bank would be bankrupt. Nonetheless, this case renders CoCos obsolete since their intended purpose is to avoid an abrupt default of a bank.

The lower-left hand balance sheet shows the alternative to a CoCo-financed bank. In contrast to the previous case, the equity requirements are drastically increased. For example, during the 2008 crisis the ratio of "hard" equity ready to absorb losses was just 3 per cent for Lehman Brothers, despite the fact that they had fulfilled regulatory capital requirements end even exceeded them with a ratio of 11.6 per cent (Johnson and Kwak, 2010). If now this equity ratio amounts to 15 per cent – see suggestions by Miles *et al*. (2011) and Kashyap *et al*. (2010) above – immediate loss-absorbency would be available. The same shock demands for writing down asset valuation and therefore writing down the value of equity. The balance sheets of a bank *ex post* conversion of CoCos and a bank with substantial equity in the first place are identical after financial losses. Therefore, so the argument, CoCos would not deliver any advantages over straight equity capital. However, Admati *et al*.'s analysis of CoCos is only driven by the following question: "If we want to enhance the bank's capital cushion, why not just require the cushion to come in the form of simple equity?" (Admati *et al*., 2013, p.53). This is a purely technical approach that focuses on the balance sheet structure and its mechanisms and does not aim at designing an incentive structure for banks and their investors. This should be the approach in order to make CoCos a macro-prudential tool that is not limited to absorb losses as they occur, but more importantly counter unsustainable risk taking in the first place.

Higher equity ratios are certainly important to increase the loss-absorbency of banks. Paradoxically, the opportunity costs of such a higher buffer may encourage more risk-taking (see Pazarbasioglu *et al*., 2011). Persaud (2009) expressed a similar point of view: The resilience of the whole financial system cannot be increased by just raising capital ratios unless it is completed by a "better match [of] risk-taking to risk-capacity" (Persaud, 2009) of banks. In terms of incentives to banks to take risks, Date (2010) argues that higher returns must be created in order to satisfy the increased number of shareholders asking for a minimum return of their investment. This could push the bank's management to engage in high-risk investments not in disregard of higher capital requirement but *because* of them.

Admati *et al*. (2013) argue from another point of view. Increasing the equity ratio decreases the bank's bankruptcy risk. Consequently, the shareholders' exposure to risk would be reduced and so would the demanded return on equity. For the same reason the interest rates on debt would decline, too. The bank would consequently be less tempted to invest in high-risk positions in order to satisfy investors' demands.

The question why there should be a reason for contingent capital[16] instead of just increasing equity capital raised by Admati *et al*. is certainly an important question any contingent capital proposal has to defend itself against. However, reducing the analytical framework to the observable capital cushion on the balance sheet is not sufficient. The research question has to be amended by an analysis of how the incentive structure of bank managers, shareholders, and contingent capital investors can be improved. The question how unsustainable risk-taking can be avoided is equally important.

Unlike raising fresh equity exactly when it is needed, CoCos are not exposed to the problem of procyclicality. CoCo contracts "will be set up in good times, they will be cheap (compared with raising capital in a recession) and easier to enforce" (Rajan, 2009). In the case of systemic distress upon the contingency event, the bank would not have to collect additional loss-absorbing capital at unfavourable conditions because for reasons of adverse selection (Herring, 2011; Myers and Majluf, 1984). Also, Kashyap *et al*. (2008) stress that additional to a higher *ex ante* equity cushion, recapitalisation must always be an option to mitigate a financial distress. New capital regulations must "pre-wire" (Kashyap *et al.*, 2008, p. 26) the private sector towards providing more equity instead of relying on government aids.

The post-conversion ownership of the bank encourages a more prudent risk strategy of the bank that simple higher capital requirements cannot. Coffee (2010) represents the legal body of literature with a different approach to exploring the potential of CoCos. In this proposal he

[16] Recall that contingent capital is further divided into CoCos and bail-in capital that are private financial contracts (Zhou *et al*. 2012) and subject to regulatory agency's discretion, respectively.

draws the attention to the post-conversion composition of a bank's shareholders. He pays particular attention to the agency relationship between bank managers and shareholders. Shareholder pressure is the main driver for banks to take excessive risks and leverage their capital ratio beyond sustainable levels. Debt holders are protected by a dilution of incumbent equity holders at a high conversion ratio of CoCos. This is a conversion at a discount when the shares after conversion are worth more than the face value of CoCos described by McDonald (2011) in section 6.3.4. After conversion, former CoCo investors are given preferred stock with significant voting rights. It is further assumed that shareholders are prone to risk and CoCo investors are naturally risk-averse. Now, after conversion, the latter are part of the shareholder group. The resulting "countervailing voting constituency" (Coffee, 2010, p. 10) would take off pressure from bank managers to accommodate the risk-tolerant shareholders' demand for a high return on investment (similarly Rajan, 2009). This idea of interfering in the ownership structure of a bank motivates the proposal for CoCos that follows in the next chapter. However, that proposal differs. It is designed to be a tool for the recovery or resolution – i.e. going concern basis and gone concern basis – of a bank and concentrates ownership to a few shareholders that are willing and able to reform the bank instead of making the shareholder group larger, like Coffee suggests.

An important preliminary result so far is that the different suggestions of the equity and incentive-related literature are not opposing each other. Higher capital ratios make banks more loss-absorbent indeed, therefore decreasing the probability of a bail-out with taxpayers' money. With the introduction of CoCos a further line of loss-absorbency can be imbedded into a bank for times of distress. Consequently CoCos are not a substitute for good supervision by authorities and not a substitute for higher equity; it is a complementary tool (McDonald, 2011; Pazarbasioglu *et al*., 2011).

CoCos can decrease the costs on a bank's creditors in a way that capital alone cannot Flannery (2009). If creditors are concerned about the bankruptcy process in which they could face severe losses, they would "curtail their involvement with troubled financial firms even before bankruptcy has become probable" (Flannery, 2009, p. 21). The bank's value is negatively affected by the uncertainty of possible bankruptcy proceedings, i.e. there is pessimism about whether the bank remains a going-concern surviving the distress or becomes a gone-concern facing bankruptcy. If an international bank has to be wound down across multiple national jurisdictions, creditors' concerns weight even higher and so do their incentives to curtail their financial exposure to the bank. For non-bank firms in the United States bankruptcy proceedings take an average of over 17 months for reorganising the struggling firm and almost four years if the aim is to liquidate the firm (Group of Thirty, 1998). Administrators that dealt with the Lehman bankruptcy estimated that US$ 75 billion were wasted due to a lack of preparation for a case of bankruptcy (Cairns, 2009).

Also, recall from chapter 2 that financial institutions are interconnected through short-term contracts such as overnight lending facilities. So in addition to the private costs to the bank's investors comes a systemic risk component due to the disruption of daily business (Herring, 2010). A sufficiently big bank that undergoes bankruptcy proceedings causes knock-on effects in these parts of the financial system and cause further social costs. The potential to save time and costs is the motivation for the next chapter to desing a CoCo bond that can recover or resolve a bank quickly and with moderate costs.

To draw a preliminary conclusion, because of their role of financial intermediaries, deposit-taking banks are naturally highly leveraged and according to the financial theory this leverage would exercise the best discipline on banks (Diamond and Rajan, 2001). McDonald (2011) finds a convincing end to this debate by saying that even if there are good reasons for a high leverage, CoCos as part of debt "permits banks to be highly levered while contributing less to systemic risk" (McDonald, 2011, p. 28). This view on CoCos, in general, would not interfere in discovering the banks' optimal leverage ratio and would not impose excessive burdens of indiscriminate capital requirements by the regulators. Calomiris and Herring (2011) go a step further and argue that CoCos have an advantage over regulatory minimum capital requirement. They enable and encourage a bank's management to quickly respond to changes in their exposure to risk with a pre-emptive equity issuance well before financial distress materialises. So, CoCos can make prudence an objective of banks' risk management.

6.5 Conclusion and implications for promoting financial stability

CoCos can play an important role in financial regulation alongside increased minimum capital requirements. The choices of the trigger event and conversion ratio of CoCos into new equity are crucial to the success of CoCos. A few authors suggest leaving the decision to convert CoCos to the regulatory agencies. In this case CoCos would be a bail-in tool. Yet there are concerns about biased regulatory agencies that could intervene too late. The majority of authors are in favour of introducing automated, market-based mechanisms for conversion.

If CoCos are converted at a premium to the CoCo investors, i.e. the value of the new equity is bigger than the nominal value of the CoCo bond, CoCo investors seek the trigger event. If it is possible to manipulate the trigger event, CoCos can destabilise the bank. If conversion is at a discount to the CoCo investors, i.e. the value of the new equity is smaller than the nominal value of the CoCo, CoCo investors would take a loss of wealth upon the trigger event. But this can exacerbate the debt overhang problem, which is explained in more detail in section 7.3.4. Incumbent shareholders might seek conversion to increase the relative value of their share in the bank. This concern abates the higher, i.e. the more prudent, the trigger level is set.

However serious problems with CoCos remain. CoCos should qualify for regulatory capital on a going-concern basis. This consequently and intuitively suggests that CoCos are not subordinated to equity at all times since CoCo investors – who have a debt claim – experience a loss of wealth before equity investors are completely wiped out. So, the current CoCo proposals defeat the intention of policy makers to make shareholders the first line of defense against losses.

In regards to a gone-concern basis, i.e. when a bank's capital cushion is depleted or it is reasonably assumed to be in due course, CoCo investors are not offered a good investment. On a gone-concern basis new equity is issued when the bank is already bankrupt and CoCo investors would receive equity with uncertain value. This is likely to come with a complete loss of wealth. Hence, CoCos would not have any purpose.

As mentioned earlier in the introduction each chapter is set to address the two research questions identified in chapter 2. Therefore, the following dissucion aims to anser:

- Do the existing CoCo proposals encourage sustainable risk-taking?
- Do the existing CoCo proposals curb systemic risk when it materialises?

As for the first question, the majority of the related literature addresses practical issues such as finding an appropriate pricing model for CoCos. However, there is a lack of analysis of the bank's incentives to change their business model as a direct consequence of the disciplining power stemming from CoCos. If it was clear beforehand that in case a bank falls short of capital to a level below the regulatory minimum and CoCos would dilute shareholders, they would monitor the bank's management and their investment decisions more closely. However, this resembles the argument that because of the high liquidity of deposits banks are under constant threat of insolvency and therefore it would be in their interest to remain safe and sound. Considering the 2008 crisis the reality lacked behind the theory. The presence of the moral hazard because of government guarantees abated the disciplining power of deposits and this can also apply to CoCos. The bank's management could stoically wait for the crisis to be over and despite some damage to the bank continue their business.

Fortunately, in anticipation of the next chapter, CoCos can be re-designed to discipline the individual manager. Rather than looking at the bank as a whole where individual managers are somewhat protected from repercussions, new regulations should allow for direct consequences for bank managers' failures.

As for the second question, the aim of CoCos is to bolster a bank's capital to avoid a bankruptcy that could cause contagion to other banks and the financial system. CoCos that are triggered on a going-concern basis reinforce a bank's capital cushion well before bankruptcy. This, in principle, helps curb systemic risk since leverage is decreased. Yet, the actual event of a bankruptcy does not occur. In the absence of proof of failure this demonstrates the precautionary nature of the "contingency" in CoCos. Because of the public service banks exercise, i.e. credit intermediation through deposit-taking and providing a payment system, a pre-emptive conversion is justified.

However, there is a contradiction between preserving banks and introducing discipline. On the one hand, the services necessary to the wider economy that are exercised by banks, are ensured to continue. On the other hand a conversion of CoCos provides the bank with a rescue and it can continue its business despite its lack to manage its loss-absorbing capital. If banks are required to issue a further tranche of CoCos after conversion it is not difficult to tell which banks are poorly managed either. It is those banks whose CoCo base is frequently renewed and converted. The paradox is that there are indications for a poorly run bank, yet the ultimate penalty in the form of bankruptcy is missing.

It is true though, that with CoCos the taxpayers' money does not stand ready to solve financial disruptions of banks. Instead, CoCos shift the burden to private investors. So, this is an important step towards making bank failures a private cost. However, this is not completely achieved by the existing CoCo proposals in the literature. The remaining issues, for example the pricing paradox, actually introduce systemic risk concerns on their own. So far, in times of systemic distress banks and their investors were exposed to the moral hazard due to implicit government guarantees to protect the functioning of the payment system and hence maintain financial stability. Therefore, a wait and see strategy was not uncommon until bankruptcy occurred eventually. If it is clearly communicated that CoCos will impose a loss of wealth on CoCo investors and incumbent shareholders alike, both groups will liquidate their investments prematurely. This can introduce further tension in the financial sector and destabilise banks. This is certainly not in the interest of regulatory agencies, banks, their investors, and the rest of the financial system.

The next chapter takes up this criticism and the gaps in the literature and proposes a different CoCo design. First, this proposal incentivises a bank's management towards moderation. Second, it curbs systemic risk not exclusively by making capital available upon a contingency, but paving the way for altering the ownership structure of the bank. Ideally this has a positive effect on the first research question. The bank managers have an incentive towards moderation since a significant change in the group of shareholders can come with a replacement in the hierarchy of the management. At the same time CoCos are made a "good deal" to increase marketability to investors.

7 Contingent capital part II: Empirical analysis and CoCo proposal

This chapter makes two contributions: First, in section 7.2 an empirical analysis investigates what drives the Coco spreads of a sample of five of the biggest CoCo-issuing banks in Europe. The previous chapter identified that there could be the threat that debt-to-equity or write-down CoCos introduce instabilities to banks. In order to clarify this, a linear regression model is used to determine whether the CoCo spread is explained by the individual bank's stock returns volatility or vice versa. In addition to the own stock returns volatility, the explanatory power of the following state variables on the CoCo spread change is investigated: the change in the equity market volatility, (the market being the Stoxx Europe 600), the change in the spread of long-term (the 10 year German government bond) against short-term (Euribor) risk-free refinancing conditions, and the change in the value of the Euribor, respectively. The empirical analysis finds that there is no causality between CoCos and stock returns. This suggests that the theoretical concerns identified in the previous chapter are not supported. This would also suggest that CoCos should be considered for the macro-prudential toolkit (chapter 4) available to support the regulatory agencies in maintaining financial stability (chapter 3). However, the results of the empirical analysis might be limited due to the relative small sample size.

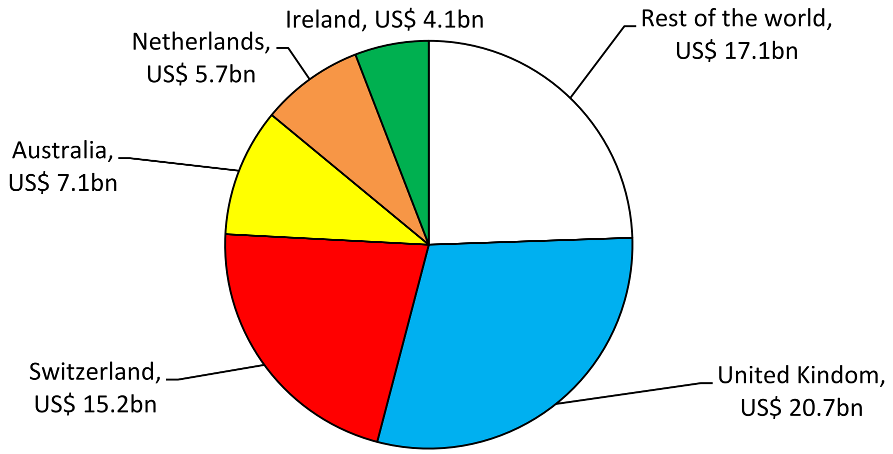
Second, section 7.3 proposes a design for CoCos to make them a macro-prudential tool that reconciles the task of incentivising banks to be more prudent and the need for a tool for the recovery and/or resolution of a distressed bank. The CoCo proposals in the current form do not offer a good deal to investors. Furthermore the lack of guidance for the time after conversion exacerbates this problem. This chapter proposes how to make CoCos a good deal to investors and, from a macro-prudential perspective, gives guidance on how to deal with a bank after CoCo conversion. The proposal thus is directly linked to the recovery and resolution authority of regulatory agencies like in the UK, USA, and EU in chapter 3. The crucial difference is that the regulatory agencies are not directly involved in the co-ordination of a recovery or resolution. This is because first, the proposed CoCos would *automatically* boost the capital cushion of a bank and, second, transfer ownership of a bank through a market mechanism instead of a costly, time consuming intervention by a public authority.

This chapter finds that CoCos, if designed properly, can abate some of the issues identified in the existing body of literature. This chapter proposes a CoCo design that helps overcome the debt overhang problem identified in the established banking theory. This is a persistent problem when a bank is close to bankruptcy but its shareholders are reluctant to inject further equity that can rescue the bank. At the same time this proposal allows CoCos to play a role as a private sector solution to orderly restructure or wind down a bank that fails. In this case the ownership of a bank can be quickly altered and therefore benefits a private sector solution.

7.1 Overview of existing contingent capital bonds and market potential

Banks around the world already issued contingent capital bonds[17] with various terms for conversion and different triggers. Policy makers did not yet draft standards for CoCos for regulatory purposes, except the notion that CoCos a worth further research. However, the currently issued CoCos do not reflect any of the regulatory aims a macro-prudential policy maker would want to see put into action. Approximately US$ 70 billion worth CoCos are issued by banks since 2009. The UK and Switzerland are momentarily the main issuers of CoCos and contribute about half of the outstanding CoCos. In the same period banks have issued US$ 550 billion of other subordinated debt and US$ 4.1 billion senior unsecured debt, see Figure 7.1 according to Avdjiev *et al*. (2013).

Figure 7.1: Contingent capital issuance by nationality of issuing banks. Source: Avdjiev *et al*. (2013)



The issued CoCos are heterogeneous in their contractual terms. For example the Dutch Rabobank issued US$ 2 billion (Financial Times online, 2011) in 2011 with a trigger of 8 per

[17] Note that throughout this thesis the term CoCo is used for those contingent capital bonds that convert debt into equity. The already issued bonds discussed in this section and in the empirical work are write-down contingent capital bonds. For the sake of readability this empirical section uses the term "CoCo" to describe the bonds of the banks in the data sample. In section 7.3, where an alternative CoCo proposal is offered, the use of the term switches back and means a "debt-to-equity" convertible bond again.

cent consolidated equity capital ratio and the coupon is 8.375 per cent. If the trigger is breached, investors would not receive equity but write their claim down by an amount that would push the equity ratio just above 8 per cent again. However, orders were about US$ 6.5 billion, indicating a high demand.

In the USA in 2012 UBS AG has raised US$ 9 billion for its US$ 2 billion write-down convertible bond offer (Reuters, 2012). The coupon for this CoCo that triggers at 5 per cent Tier 1 common equity and writes down to zero is 7.625 per cent.

In 2013 the Credit Suisse placement of EUR 1.25 billion worth of CoCos with a maturity of 12 years attracted a demand in the financial markets worth EUR 3.15 billion (Reuters, 2013). Similar to the Rabobank issuance, this first Euro-denominated contract does not stipulate a conversion into equity. Notwithstanding the terms that upon conversion at 5 per cent of Tier 1 equity ratio all claims would be written down immediately, 85 per cent of CoCos have been purchased by institutional investors.

CoCos in the form of the above examples underscore that the unsecured investors are fully aware and agree on a write-down of their claim. However, this stays in stark contrast to the CoCo proposals in the literature. A struggling bank's management has the incentive to actively seek the trigger event to release CoCo investors. From a regulatory agency's point of view, this is a dangerous tightrope walk of the bank for it has every incentive to eliminate CoCo but are not disciplined enough to avoid the trigger event in the first place. The opposite is true because the "contingency" can be largely controlled by and therefore favours the bank. The regulatory objective of maintaining financial stability is not fulfilled by CoCos in the current forms.

7.2 Empirical analysis of a selection of contingent convertibles

This section contains an empirical analysis of a selection of already issued CoCos of European banks. The analysis investigates which factors affect the change in the spread of the CoCos. The various currently available CoCos can introduce imbalances a macro-prudential policy maker should be concerned of. Originally the "contingency" of CoCos should stabilise a bank when it is in distress. However, this can have the opposite effect, as analysed in the previous chapter. The possible destabilising effects of CoCos in their current form find anecdotal evidence in the case of Deutsche Bank (Steltzner, 2016). In the course of re-shaping its business model the bank is under constant scrutiny of the markets. Deutsche bank was one of the first European banks in 2014 to issue CoCos worth EUR 5 billion and pay a coupon of 7 per cent. The trigger is set to a capital ratio of 5.125 per cent and upon this contingency a temporary write down is imposed on the CoCos. The outspoken aim of CoCos is to boost the financial situation of a bank to mitigate distress that could lead to systemic risk concerns. However, because of its restructuring efforts Deutsche Bank announced a cut on dividend payments – which a regulatory agency welcomes for this should take some financial burden off a bank – and furthermore felt the need to repeatedly reasuure to meet its obligations on CoCos. In early February 2016 this resulted in a drop of the stock price due to markets' concerns.

The existing CoCos do not follow a standardised "terms and conditions" contract that specifically sets out the kind of the trigger, the trigger level, and what happens at the trigger event, i.e. a partially or full write down, conversion into new equity, and if so at what conversion rate. The financial markets are still making experiences in designing and trading CoCos. So, the CoCo market is heterogeneous. In order to make the CoCos comparable it is not the purpose of this section to empirically trace what determines the *price* of CoCos; instead, this section analyses how the CoCos yield *spreads* over a risk-free government yield change to common factors.

For example, if the whole banking sector is under distress one would intuitively expect CoCo spreads to increase. The threat of touching the trigger moves closer so that a loss of wealth becomes a realistic prospect for the CoCo investors. Besides, not only does the volatility of a macro-level indicator could have an effect on CoCo spreads, but also the micro-level, like in above example of Deutsche Bank. Hence a bank's equity volatility should have an effect on its CoCo spread.

This chapter is one of the first empirical studies about CoCos. De Spiegeleer et al. (2015) find a moderately negative impact on prices of outstanding CoCos when a bank issues new CoCo, investors tend to prefer investing in new CoCos. De Spiegeleer et al. (2015a) empirically investigate how CoCos affect the core equity tier 1 (CET1) ratio. CET1 is the regulatory capital requirement banks have to produce, but banks regularly exceed the minimum threshold to make sure not to fall under the minimum. The authors find that CoCos issued by the same bank with similar, but not identical, terms of conversion have an identical impact on the volatility of the bank's CET1 level. So, while on the one hand banks have more equity to absorb losses, its ratio above the regulatory minimum is exposed to volatility because of CoCos. This chapter takes a different angle and further investigates the relationship between the observed returns on a bank's stocks and its CoCo returns. Furthermore, this chapter is the first to investigate which market factors – e.g. a bank's stock returns, market equity returns, short-term liquidity, and government benchmark spread – drive the change in the spread of CoCos.

7.2.1 Data and descriptive statistics

This sub-section discusses the observed time series of the CoCos. The CoCo bonds subject to this analysis are from Barclays, Lloyds, Credit Suisse, UBS, and Unicredit. Table 7.1 provides the terms of these CoCos and their ISINs.

Table 7.1: Overview of bank's CoCo terms

Issuing bank	Coupon	Perpetual	Callable	Capital	Trigger	ISIN
Barclays	7.63%	No	No	Tier 2	7%	US06740L8C27
Lloyds	15%	No	No	Tier 2	5%	XS0459089685
Credit Suisse	7.88%	No	Yes	Tier 2	7%	XS0595225318
UBS	7.25%	No	Yes	Tier 2	7%	XS0747231362
Unicredit	9.38%	Yes	Yes	Tier 1	6%	XS0527624059

The CoCo issued by Unicredit is the only perpetual bond in the list. A perpetual bond has no maturity date at which the principal is paid back in full and any coupon payment comes to a halt. Once issued – in theory – a perpetual pays its coupon indefinitely. The other bonds have a given maturity. For example the Barclays CoCo issued in November 2012 matures in November 2022. The CoCos can either mature on the given date or the bank can call them back.

Because it is perpetual, the CoCo of Unicredit qualifies to be treated as Tier 1 core capital. Because of the lack of a definite, contractually agreed maturity date, it can be treated similar to equity. For the other banks, their CoCos contribute to Tier 2 capital. So, a bank's decision whether to call back the outstanding CoCos carefully depends on a trade-off: If the CoCo bonds are traded below their face value, for example 85 per cent, the bank can buy back its own outstanding debt cheaply. On the other side, by doing so the loss-absorbing regulatory capital cushion is diminished which is possibly punished by the markets in the form of decreasing stock value.

The trigger levels are set to below Basel III minimum capital requirements. Yet, the coupons on the CoCos differ considerably. With 15 per cent Lloyds pays almost twice as much as Barclays and the two Swiss banks. Unicredit pays over 9 per cent and is the only bank that pays annually, the others pay the coupon bi-annually.

The explanatory variables used to analyse what explains the changes in the CoCo spread are:

(i) The market volatility is estimated using data from the Stoxx Europe 600 index that covers approximately 90 per cent of European equity returns.

(ii) The government spread is the difference between the 10 year German government bond, which is a benchmark for riskless investment, and the short-term refinancing conditions Euribor.

(iii) The Euribor itself also serves as the short term yield.

The banks' stock returns volatility is expressed with the log returns in the form of

$$\sigma_t = |r_t| \tag{7.1}$$

where

$$r_t = \ln(P_t) - \ln(P_{t-1}) \tag{7.2}$$

with P_t denoting the stock price for the bank in period t and P_{t-1} denoting the stock price in the previous period. Using the log returns rather than simple returns find an argument in Hudson and Gregoriou (2010). The authors compare the two approaches and apply the two alternative ways of calculating returns on different numerical examples. They find that the mean returns are lower for the log return approach than for the simple returns method. As a consequence, the statistical significance of the results of any empirical study could be reported differently. So the results could be rejected under the one approach but not under the other approach. The relevance of this argument gains importance with the frequency of the collected observations. The higher the frequency, i.e. collecting intraday data versus weekly data, the more suitable is the log return approach. The empirical study at hand uses daily stock prices that are converted into daily returns. Hence the log return approach is used.

Also the results for every CoCo are compared to the yield of different benchmarks. The spread of all banks are represented by the IBOXX Euro Corp bank index, the private sector benchmark of prime credit rating is the IBOXX Euro AAA index, and the IBOXX Euro BBB index represents the lower medium grade ratings.

Table 7.2 below reports the summary statistics of the volatility of stock returns of the CoCo issuing banks. These statistics are discussed when the respective CoCo bond spreads are presented. The same applies to the summary statistics of the change of the CoCo spreads, reported in Table 7.3.

Table 7.2: Summary statistics for the volatility of bank stock returns.

Bank	Min.	Max.	Mean	Median	Std.	Skewness	Kurtosis
Barclays	-0.343	0.508	0.000506	0.000525	0.0370	1.3131	30.7121
Lloyds	-0.415	0.408	-7.00E-05	5.08E-05	0.0365	-1.1843	38.0387
Credit Suisse	-0.152	0.15	6.34E-05	0	0.0236	-0.3354	5.860962
UBS	-0.116	0.13	-0.00015	0	0.0227	0.1391	3.8622
Unicredit	-0.19	0.19	-0.00042	0	0.0316	-0.1260	4.1108

Table 7.3: Summary statistics for the change of bank CoCo spread.

Bank	Min.	Max.	Mean	Median	Std.	Skewness	Kurtosis
Barclays	-0.925	1.250	-0.0026	-0.0125	0.2364	0.3590	5.439
Lloyds	-0.469	0.648	-0.0045	-0.002	0.0691	0.2348	20.3269
Credit Suisse	-0.401	0.308	0.0008	0.001	0.0913	-0.3094	4.7006
UBS	-0.616	0.615	0.0013	0.0005	0.1534	-0.0609	4.6405
Unicredit	-0.070	0.073	-0	0.0009	0.0202	-0.1017	3.9667

Figure 7.2 Barclays Coco Spread vs. Bond Index Spreads

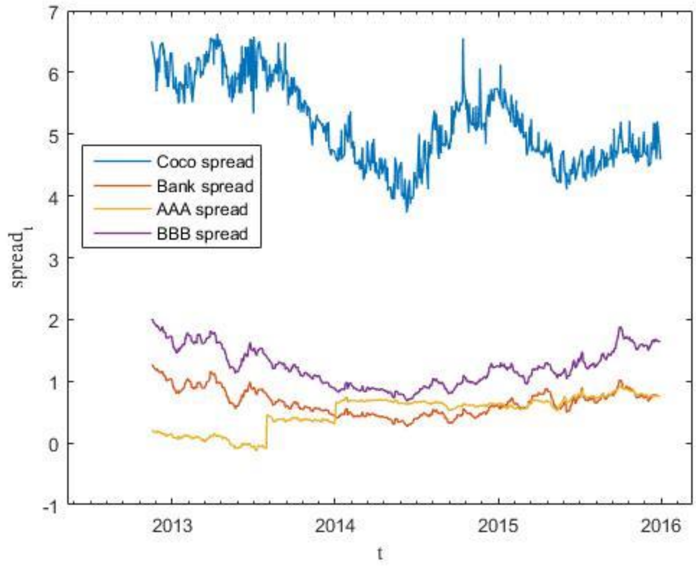


Figure 7.2 shows the Barclays CoCo spread over the various benchmark spreads. With a standard deviation of 0.2364 this CoCo has the highest volatility of change of the spread compared to the other banks' CoCos, see results appendix. It also has the most extreme values for changes of the spread of -0.925 and 1.25 percentage points. Also, Barclay's stock returns volatility and changes are among the highest of the five banks. However, from early 2015 on it has the lowest spread of all CoCos with around 4.5 percentage points.

The bank spread is the change of the spread of the IBOXX Euro Corp. Bank index over the 10 year German government bond. The AAA spread is the change of the spread of the IBOXX Euro Corp. AAA rated bonds index over the 10 year German government bond. The AAA rated bonds represent the highest tier of investment grade rated corporate bonds, so are of highest credit quality. The BBB spread is the change of the spread of the IBOXX Euro Corp. BBB rated bonds index over the 10 year German government bond. The BBB rated bonds represent the lowest tier of investment grade rated corporate bonds, indicating a medium credit quality. Bonds with a BBB rating are just above non-investment grade, which is speculative grade.

Figure 7.3: Lloyds Coco Spread vs. Bond Index Spreads

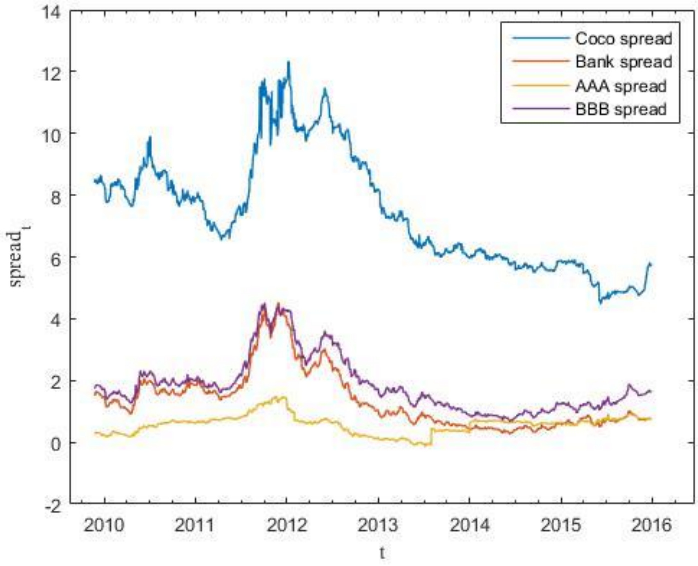


Figure 7.3 hows the Lloyds CoCo. It experiences the second largest spreads, after Unicredit below. It peaks at 12 percentage points in early 2012.

In comparison the other banks peak at just below 7 percentage points. Interestingly Lloyds' stock returns volatility is 0.0365 and the highest of all banks, see Table 7.2 above, but the Coco spread volatility is the second lowest with 0.0691.

Figure 7.4: UBS Coco Spread vs. Bond Index Spreads

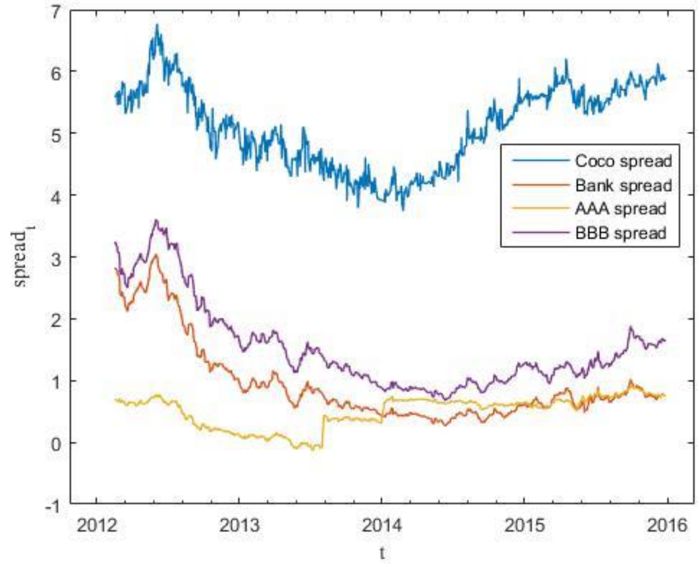


Figure 7.4 shows the UBS CoCo. It has the second highest spread volatility with a standard deviation of 0.1534, see Table 7.3, but the stock returns volatility is the lowest of all banks with 0.0, see Table 7.2.

Figure 7.5: Credit Suisse Coco Spread vs. Bond Index Spreads

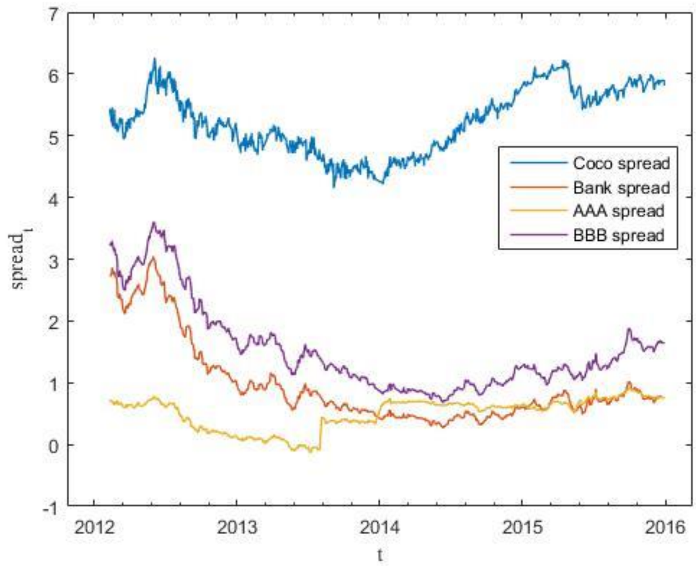


Figure 7.5 shows that the CoCo of Credit Suisse follows a similar pattern to the one of UBS. However, the mid-2012 peak spread is slightly lower. The stock returns volatility is slightly higher than the one of UBS, yet with 0.0913 the overall CoCo spread volatility is lower than the one of UBS, see Table 7.2 and Table 7.3, respectively.

Figure 7.6: Unicredit Coco Spread vs. Bond Index Spreads

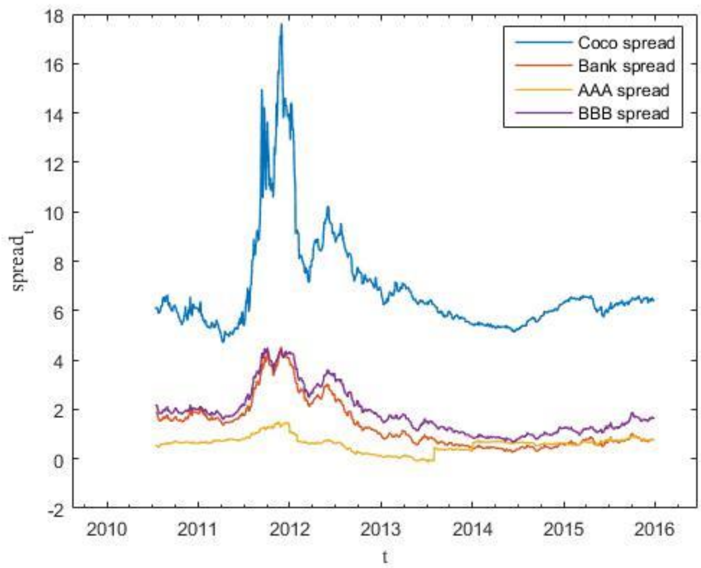


Figure 7.6 indicates that the CoCo of Unicredit has the highest spread of all CoCos of almost 18. From approximately mid-2012 on the spread follows the other CoCo's pattern within a band of 5 to 7.

The stock returns volatility is in the mid-field of the five banks in the sample with 0.0316, see Table 7.2. But the volatility of the change in the CoCo spread is the lowest, see Table 7.3.

7.2.2 Linear regression model

This sub-section contains the presentation of the linear regression model to test which variable affects a bank's change of the CoCo spread, i.e. the 1st difference rather than level. The spread of a bank's CoCo is defined as the difference of the CoCo's yield in period t and the long-term risk-free benchmark, here the 10 years German government bond. Expressed in algebraic terms:

$$Y_t = CoCo_t - LGY_t \tag{7.3}$$

In order to investigate the relation between the change of CoCo spreads and the financial system factors, a linear regression analysis is performed. The time series of the change of CoCo spreads are regressed on the time series of the factors. This section presents the linear regression model that is used. Section 7.2.3 analyses whether the time series used in this empirical analysis are stationary. Section 7.2.4 presents the regression results and additional testing for Granger-causality of the results.

For each CoCo a linear factor model is estimated to analyse what explains the changes in the respective bank's CoCo spread. For the linear model the ordinary least squares (OLS) regression is applied. In general terms the aim of an OLS regression is to estimate by what amount a variable y, the dependent variable, changes if a factor, or explanatory variable, changes by one unit. More formally this is captured by the following model:

$$\boldsymbol{y} = \boldsymbol{\beta X} + \epsilon. \tag{7.4}$$

The $\boldsymbol{y}$ is the dependent variable. The $\boldsymbol{\beta}$ is the beta factor that captures the average contribution of the explanatory variable $\boldsymbol{X}$ on the change in $\boldsymbol{y}$. The ϵ is the error term that captures the change that is not captured in the $\boldsymbol{\beta}$. Note that the equation uses a matrix notation as indicated by bold font. This means that not only one explanatory factor is captured but a number of n factors are in $\boldsymbol{X}$. The same applies to y that contains all dependant variables and their respective error terms, captured in ϵ.

The $\boldsymbol{y}$ is a $n \times 1$ dimensional vector, where n denotes the number of observations in the time series of the dependant variable. Applied to the empirical analysis of the time series of the CoCo bond spreads, here the vector y contains the time series of the change in CoCo spread. The $\boldsymbol{X}$ denotes a matrix containing the time series of independent, i.e. explanatory, variables and a constant in columns. So, the matrix $\boldsymbol{X}$ consists of a number of k explanatory variables. Each observation t of the independent variables can be expressed with the vector $x_t = (1, x_{t,1}, x_{t,2} \dots, x_{t,k})$, where 1 denotes the constant. Each of the other elements can be addressed with $x_{t,j}$, which is the t^{th} observation of the explanatory variable j. All explanatory variables are summarised in $j = (1, 2, \dots, k)$. The matrix $\boldsymbol{X}$ has the dimension $n \times (k+1)$ because the length of the time series of the explanatory variables must necessarily match the number of observations for the dependant variable, here n, and the number of explanatory variables k is extended with a constant. The vector of parameters, i.e. regression coefficients in the results section 7.2.4, for the explanatory variables is denoted by $\boldsymbol{\beta} = (\beta_1, \beta_2, \dots, \beta_k)$, which has the dimension $(k+1) \times 1$ since there is one parameter for each explanatory variable's time series and one parameter for the constant. Finally the $n \times 1$ dimensional vector ϵ denotes the unobservable errors. The change in each bank's CoCo spread is estimated with the linear regression model

$$\Delta Y_t = \alpha + \beta_1 X_{1t} + \beta_2 X_{2t} + \beta_3 X_{3t} + \beta_4 X_{4t} + \epsilon_t \tag{7.5}$$

with ΔY_t denoting the change in the spread in period t (i.e. the 1$^{\text{st}}$ difference), α is the constant, the β are the parameters that need to be estimated, the Xs are the explanatory variables, and an error term ϵ for period t. The explanatory variables that can explain the change in the CoCo spread of a particular bank are:

$$X_{1t} = \Delta\sigma_{mt}\ , \tag{7.6}$$

$$X_{2t} = \Delta\sigma_t\ , \tag{7.7}$$

$$X_{3t} = \Delta(LGY_t - SGY_t)\ \text{, and} \tag{7.8}$$

$$X_{4t} = \Delta SGY_t. \tag{7.9}$$

The $\Delta\sigma_{mt}$ denotes the volatility of returns for the market (the market being the Stoxx Europe 600) (7.6), $\Delta\sigma_t$ denotes the volatility of returns for the bank (7.7), $\Delta(LGY_t - SGY_t)$ denotes the change in the spread of long-term (10 year German government bond) against short term (Euribor) risk-free refinancing conditions (7.8), and ΔSGY_t denotes the change in the value of the Euribor (7.9), respectively, all in period t. Table 7.4 provides the summary statistics of their change, so the 1st differences rather than their levels.

Table 7.4: Summary statistics of the 1st differences of the explanatory variables.

Explanatory variable	Min	Max	Mean	Median	Std.	Skewness	Kurtosis
Market volatility	-0.0643	0.0468	-0	-0.0001	0.0094	-0.1571	6.2131
Gov. bond spread	-0.225	0.251	0.0012	0.002	0.0488	-0.2503	5.3091
Euribor	-0.092	0.064	-0.0006	0	0.0064	-4.2561	78.6674

7.2.3 Testing the regression data for stationarity

In order to investigate whether the linear regression model that is used is appropriate, in this sub-section the augmented Dickey-Fuller (ADF) test analyses every time series for a unit root. If a unit root is present, then the particular time series is not stationary and vice versa. Stationarity means that the mean and variance of the collected data do not change or follow a trend over the whole observation period. For example, the stock price of a company can follow a trend because the company sells products that happen to be subject to seasonal demand (think of U.S demand for pumpkins at Halloween). The issue is that in the presence of non-stationarity of the time series the regression coefficients cannot be validly tested.

The important aspect of such a shock (seasonal demand) on the stationarity of the times series is that the initial shock in period t abates over the next periods $t + 1$, $t + 2$, etc. Contrary for non-stationary data the initial shock persists and does not become smaller in periods $t + 1$, $t + 2$, etc. A regression of two non-stationary time series leads to the problem of spurious regressions. Regardless whether the one time series can actually explain the other – causality is tested for in the results section 7.2.4 – two trending time series can produce a regression that looks convincing, i.e. the coefficient estimates are statistically significant and the R^2 indicates that a high percentage of the dependant variable can be explained by the independent variable.

The ADF test is executed with one-lagged, two-lagged, three-lagged, four-lagged, and five-lagged models. More formally, this is expressed as an autoregressive models of the orders AR(1), AR(2), AR(3), AR(4), and AR(5) An absence of a unit root means that the time series is stationary. More formally, the time series is identified as integrated of order zero, $I(0)$. If the time series has a unit root, the time series is integrated of order one, or $I(1)$. The hypotheses that are tested on a 5 per cent confidence level are:

H(0): There is a unit root, therefore the series is not stationary

H(1): There is no unit root, therefore the series is stationary.

The ADF test is performed to investigate stationarity of the time series of the banks' CoCo spread (Y_t) and the banks' stock returns volatility (7.7), the three other explanatory variables of the linear regression model (7.5), i.e. market volatility (7.6), the government bond spread (7.8), and the short term liquidity measure (7.9). Also the bond index for European corporations (IBOXX Euro Corps.) and the bond index specifically for banks (IBOXX Euro Corps. Banks) are tested for stationarity. These two indices are used to give a rounded view on the empirical analysis. As the example of Deutsche Bank from the introduction shoes, there might be bi-directional causality between CoCos and shares of a bank. The next section investigates whether bonds in general cause equity volatility or the other way round. Table 7.5 provides the summary statistics of the change of the two indices, so the 1st differences rather than their levels.

Table 7.5: Summary statistics for the 1st difference of corporate and bank bond indices.

Name	Min	Max	Mean	Median	Std.	Skewness	Kurtosis
IBOXX Euro Corps.	-0.1868	0.1842	0.0001	-0.0006	0.0312	0.155	8.2092
IBOXX Euro Banks	-0.3361	0.315	-0.0005	-0.002	0.0435	0.1625	13.9082

For the following results, compare the results appendix: For all banks across all nth lag models the H(0) is rejected on the 5 per cent level, suggesting that the time series are stationary (Table 7.6 to Table 7.10). Also, across all n^{th} lag models the H(0) is rejected for the two bond indices, suggesting that these time series are stationary (Table 7.11). Across all n^{th} lag models the H(0) is rejected for the explanatory variables, suggesting that these time series of the first differences are also stationary (Table 7.12). The same test is conducted and reported in table 7.12 for the level of – not change in – the respective time series. The level equity market is stationary, the level of government spread and short-term refinancing conditions are not. All first differences tested using the ADF test with different lag lengths suggest that all of the time series are stationary. Thus, the simple regression model can be used to analyse what explains the changes in the banks' CoCo spreads.

7.2.4 Linear regression results

This sub-section reports the linear regression results to answer the direction of causality between the CoCo spread and stock returns of a single bank. The Granger causality test (Granger, 1969) identifies the direction of causality or whether one time series, i.e. explanatory variables (see data section), can actually be used to determine another time series. This goes beyond simple correlation and seeks to reveal a true causation. So, despite a statistical significance it is not necessarily plausible that the one time series can *actually* be used to forecast the other.

Granger causality means that if an observation of variable x causes y, then past observations for x should contain predictive information about y that are beyond past observations of y itself, i.e. auto-regression. In addition to the requirement that x happens prior to y, if x, compared to any other variable, seem to contain *unique* information to predict future values of y, then one can speak of causality. This is the advantage of introducing the Granger causality element over an orthodox linear regression. A linear regression alone produces estimates for the different variables chosen to be in the formula. Yet, the Granger causality hints to the direction of causation and not blunt correlation.

In this empirical research the likelyhood ratio test version of the Granger causality is used, that produces equivalent F-test formula (note that Tables 7.13 to 7.19 in the results appendix abbreviate the the likelihood ratio to LR and the p-values indicate the critical value for rejecting the H(0)). This means that Granger causality from a time series x to y is inferred by calculating the relative reduction of the likelihood of y by the exclusion of x compared with the likelihood obtained using all the time series. So, a variable x does not Granger-cause y if for all $h > 0$ if the following equation holds true:

$$P(y_{t+h}|A_t) = P(Y_{t+h}|A_t - x_t) \tag{7.10}$$

P refers to probability, A_t is the set of all information available in the universe at time t, $A_t - x_t$ is the set of all information available in the universe at time t but without the unique information carried by the variable x. In simple words, if the above equation holds true, x carries no unique information about y that is available somewhere else in A, hence x does not help predict y.

$$y_t = a_0 + a_1 y_{t-1} + a_2 y_{t-2} + \cdots + a_m y_{t-m} + b_p x_{t-p} + \cdots + b_q x_{t-q} + \epsilon_t \tag{7.11}$$

Let y and x be stationary time series. To test the null hypothesis, H(0), that x does not Granger cause y, first the lagged values of y are included in univariate auto-regression, as denoted. Second, the lagged values of x are added and an error term. The H(0) is not rejected if and only if no lagged values of x are retained in the regression.

Caution must be exercised since a Granger causality could also be explained by a joint, third explanatory factor that has not been considered in setting up the model. However, the questions Q1 to Q7 below aim to answer the directionality between bond prices and share prices, micro-level individual bonds vs. shares and macro-level bond index vs. equity index. Nevertheless, comparing bonds to stocks are a popular field of financial research and represent the two sides of the same coin in corporate finance.

In regards to the empirical analysis of this chapter, one direction could be that the volatility of a bank's stock returns affects the change in the bank's CoCo spread. The other direction is that the change in spread has an effect on the volatility as the example of Deutsche Bank in the introduction might suggest.

For example the current period's stock returns could be explained by the previous period's stock returns and change of the CoCo spread. There might also be a feedback, so that the change of the CoCo spread could explain future stock returns. The hypotheses that are tested on a 5 per cent confidence level are, in general terms:

H(0): The one times series does not Granger-cause the other time series.

H(1): The one times series does Granger-cause the other time series.

Applied to the data used in this chapter the Granger causality test helps answer the following questions about the time series of the five banks i = (1, 2, 3, 4, 5) in the sample:

Q1: Does the stock returns volatility of bank i Granger-cause the change of the CoCo spread of bank i?

Q2: Does the market volatility Granger-cause the change of the CoCo spread of bank

i?

Q3: Does the change of the CoCo spread of bank i Granger-cause the stock returns volatility of bank i?

Obviously Q3 is asking the reverse of what Q1 is asking, so the test undertaking also covers the possibility of a feedback effect between the stock returns and change of CoCo spreads. These three different regresions are each vector auto regressions (VAR) of different orders, here executed for up to five lagged periods. For example, this means that Q1 investigates whether the stock returns volatility of bank i in period $t-1$ causes the change of the CoCo spread of bank i in period t; whether the stock returns volatility of bank i in periods $t-1$ and $t-2$ cause the change of the CoCo spread of bank i in period t etc. all the way up to whether the stock returns volatility of bank i from all periods together since $t-5$ cause the change of the CoCo spread of bank i in period t.

Recall from the previous chapter the pricing issues that are identified by the financial theory literature. Suppose that CoCos are intended to be automatically converted into equity at a low trigger where a bank can become a gone concern, i.e. facing bankruptcy. If CoCos are designed to be converted into shares of a struggling bank, the spread increases. A conversion of CoCos into new equity dilutes existing shareholders' wealth, so the share price drops. A decrease in share prices is a sign for decline in health of a bank, so CoCo investors are concerned that the trigger will be pulled soon so that the CoCos convert, markets will price this risk with a higher spread etc. Similar concerns are spread when markets see permanent write-offs on CoCos.

The Granger causality test is also applied to the bond index of the wider economy and the bond index of the banks to answer the questions:

Q4: Does the market volatility Granger-cause the bond index spread?

Q5: Does the index bond spread Granger-cause the market volatility?

Q6: Does the market volatility Granger-cause the bank bond index spread?

Q7: Does the bank bond index spread Granger-cause the market-volatility?

Similar to Q1 and Q3, here Q5 is asking the reverse of Q4 and Q7 the reverse of Q6. Again, just like Q1 to Q3, each VAR is gradually expandend up to the fifth lag of the respective variable, i.e. VAR(1) to VAR(5). Theoretically, there can be intermarket relationship between bond markets and equity markets. Both markets can go in the same direction if the financial markets are generally confident in the future of an economy. A growing company can make its interest payments on its bonds and profits still grow. Therefore its stocks become also attractive to investors. If markets are confident in the whole economy the price for both bond and stock markets move up. The economic environment also plays a role in determining the direction of the two markets. If the central bank increases the interest rates, stocks are less attractive since interest payments of newly issued bonds will eat into company profits. However, newly issued bonds are perceived relatively more attractive than stocks because of the higher interest rate. Consequently stock prices decrease, bond prices increase. However, during a prolonged period of low interest rates stock prices can go up because interest payments do not eat into profits. The bond market can also increase. This depends on how many old bonds with relative high interest are still in the markets. With fewer opportunities for higher returns, investors can still be invested in bonds because they are safer than stocks. This co-movement is particular plausible if investors are sceptical about how long the interest rates remain so low, they simply invest in both markets.

However, if it turns out that in general the spreads in bond markets – for the purpose of CoCos especially the bank-related bonds – and volatility in equity markets are unrelated, one can better locate the results of the analysis of Q1 to Q3. For example, if the results are in support of Q1, this suggests that a bank's stock returns volatility causes its CoCo spread. It is important to know wheter this also holds true in a general setting, e.g. the European stock volatility cause the spread of the bond markets. Also, the bank bond market is included, which is a sub-set of the European bond market index, to double check for differences. Different results can lead to suggesting that CoCo bonds, because of their unique design, are different to normal bonds and affect bank's equity in a unique way that does not correspond with the other intermarket analyses as indicated by Q4 to Q5.

Intuition would suggest that the more parameters are used in a linear regression model like (7.5) the better the fit. However, too many explanatory variables can lead to an overfitting model. The Bayesian Information Criteria (BIC), developed by Schwarz (1978), is a criterion to select the most suitable model out of a selection of available models. In simple terms, the BIC assesses each model of its likelihood to be the appropriate model. The BIC introduces a penalty term that is the product of the number of parameters times the logarithm of the number of observations of the data. The idea is to consider parameter uncertainty and estimation uncertainty. Hence, a penalty is automatically attached to each additional parameter. To compensate for this, the explanatory power of the parameter must be sufficiently high so one can speak of strength of evidence. If one model has a lower BIC than another, this could be due to fewer explanatory parameters that are penalised, a better fit, or both. So, the model with the lowest BIC value is selected. In direct comparison one can speak of strong evidence against a model its BIC is reater than 10 compared to the lowest BIC model. For smaller differences of 0 to 2 the difference is not worth metioning, see Kass and Raftery (1995) for details.

In this empirical analysis the linear regression model applied to each bank only uses four explanatory variables of different kinds, e.g. a risk-free investment, a comparable risk benchmark, and a liquidity indicator. The Granger causality test is designed to compare five models with different lag, i.e. the 1st, 2nd, 3rd, 4th, and 5th lag. The number of explanatory variables stays constant. The intended outcome of the BIC test aims at selecting the models with the appropriate lag to answer the questions Q1, Q2, and Q3, see above. Hence a lower BIC suggests a better fit. So, out of these models for each linear regression, only one is used to give a definite answer for the causality. Note that in the results tables the statistical p-value lower than 0.05 leads to the rejection of H(0) that there is no causality on the 5 per cent level.

Also the estimates $\hat{\beta}_i$ for each of the parameters of each independent (or explanatory) variable (7.6) to (7.9) are tested for statistical significance. So the H(0) is that the parameter is zero, hence is not significant and does not explain the CoCo spread. A rejection of the H(0) leads to accepting the H(1) which is indicated that the parameter is different from zero, hence explaining the CoCo spread. Furthermore, note that for the respective regression for each bank all four independent variables are used plus a constant, indicated by $\hat{\alpha}$ in the respective table. The linear regressions on the corporate bond index and bank bond index does not use the individual bank's returns as explanatory variable but only uses the Stoxx equity returns ($\hat{\beta}_1$), government spread ($\hat{\beta}_2$), and Euribor ($\hat{\beta}_3$).

7.2.4.1 Granger causality and linear regression results for Barclays

[Insert Table 7.13 about here]

For the sake of readability the tables in this and the following sub-sections are listed in the results appendix and are referred to in the text. So, for the Granger causality analysis for Barclays compare Table 7.13 in the results appendix. The likelihood ratio (LR) columns in table 7.13 are the test statistics for testing the H(0) versus the alternative H(1). The H(0) of Q1, Q2, and Q3 is not rejected for the 1st lag VAR model, or VAR(1) since all p-values are larger than 0.05 and has the lowest BIC. This means that neither Barclays' stock returns volatility, nor the equity market volatility in general Granger-cause Barclays' CoCo spreads. Also, Barclays' CoCo spread does not Granger-cause Barclays' stock returns volatility. Note that the H(0) is rejected for the VAR(5) of Q3, suggesting that including lags up to the 5th period of the change of the CoCo spread Granger-causes Barclays' stock returns. However, the difference between the BIC of the VAR(5) model and VAR(1) model is significant, so that the VAR(5) model is probably over-fitted.

[Insert Table 7.20 about here]

Next the linear regression results for Barclays can be obtained from Table 7.20 in the results appendix. The CoCo spreads are regressed on the explanatory variables (7.6) to (7.9) according to section 7.2.2. The estimates for the true beta factor β is $\hat{\beta}_{it}$ for the explanatory variable i in period t, for Barclays are shown in Table 7.20. Only the $\hat{\beta}_{3t}$, i.e. government bond spread, is statistically different from zero, because of negative t-statistics smaller than -1.96, and explains the Barclays CoCo spread. An increase of 1 in the Government spread results in a decrease of the CoCo spread of 1.19. However, the model that is suggested to explain the CoCo spread only explains approximately 0.04 per cent, according to the R^2.

7.2.4.2 Granger causality and linear regression results for Lloyds Bank

[Insert Table 7.14 about here]

For the Granger causality analyses for Lloyds compare Table 7.14 in the results appendix. The H(0) of Q1, Q2, and Q3 is not rejected for the VAR(1) model, which has the lowest BIC. This means that neither Barclays' stock returns volatility, nor the equity market volatility in general Granger-cause Lloyds' CoCo spreads. Also, Lloyds' CoCo spread does not Granger-causes Lloyds' stock returns volatility. Note that the H(0) is rejected for the VAR(4) and VAR(5) model for Q3, suggesting that the vector auto regression up to the 4th and 5th lag of the change of CoCo spread Granger-causes Lloyds' stock returns. However, the difference between the BIC of each model and 1st lag model is significant, so that the VAR(4) and VAR(5) models are probably over-fitted.

[Insert Table 7.21 about here]

Next, the linear regression results for the Lloyds CoCo are shown in Table 7.21 in the results appendix. Interestingly, Lloyds is the only bank for which two explanatory variables are statistically significant in terms of explanatory power. These are $\hat{\beta}_{3t}$ and $\hat{\beta}_{4t}$, or the government spread and the short-term refinancing conditions of the 3-months Euribor, respectively. Of all banks the explanatory power of the government spread is the lowest with -0.88. An increase in the Euribor, however, comes with a decrease of the spread of 1.60. Only 7 per cent of the CoCo spread can be explained with the regression model.

7.2.4.3 Granger causality and linear regression results for Credit Suisse

[Insert Table 7.15 about here]

For the Granger causality analyses for Credit Suisse compare Table 7.15 in the results appendix. The H(0) of Q1, Q2, and Q3 is not rejected for the VAR(1), which has the lowest BIC. This means that neither Credit Suisse's stock returns volatility, nor the equity market volatility in general Granger-cause Credit Suisse's CoCo spreads. Also, Credit Suisse's CoCo spread does not Granger-causes Credit Suisse's stock returns volatility.

Note that in contrast to the previous two banks the H(0) is rejected for the VAR(3), VAR(4), and VAR(5) model of Q2, suggesting that these lagged vectors of the equity market volatility Granger-causes Credit Suisse's CoCo spread. However, the difference between the BIC of each model and 1^{st} lag model is significant, so that the regression models up to the 3^{rd}, 4^{th}, and 5^{th} lag are probably over-fitted.

[Insert Table 7.22 about here]

The linear regression results for Credit Suisse CoCo are shown in Table 7.22 in the results appendix. The government bond spread is the only statistically relevant explanatory variable in the regression model, but with a strong t-statistic. Of all banks in the sample the government bond spread has an impact on the CoCo of Credit Suisse of -1.06. Again, the government bond spread is the only explanatory variable that is significantly different from zero since the t-statistic is -16.5 this shows that the change in government spread tends to be high in magnitude. Also interestingly, in contrast to the other banks 26 per cent of the Credit Suisse's CoCo spread can be explained with the regression model. The other Swiss bank in the sample is UBS, see below. The terms and conditions of the CoCos are identical, except that Credit Suisse offers a slightly higher yield. The patterns on the spreads – not the change of spreads – are almost identical. Also the summary statistics of both bank's CoCos and stock returns are close.

7.2.4.4 Granger causality and linear regression results for UBS

[Insert Table 7.16 about here]

For the Granger causality analyses for UBS compare Table 7.16 in the results appendix**.** The H(0) of Q1, Q2, and Q3 is not rejected for the VAR(1), which has the lowest BIC. This means that neither UBS' stock returns volatility, nor the equity market volatility in general Granger-cause UBS' CoCo spreads. Also, UBS' CoCo spread does not Granger-cause UBS' stock returns volatility.

Note that the H(0) is rejected for the VAR(4) of Q2, suggesting that the vector regression up to the 4^{th} lag of the CoCo spread Granger-causes UBS' stock returns. However, the difference between the BIC of this model and the VAR(1) is significant, so that the model is probably over-fitted. Furtehrmore, the VAR(2) and VAR(5) reject the H(0) for Q3, suggesting that there is a Granger-causality of CoCo spread on stock returns. Again, the BIC results suggest strong evidence against these two models.

[Insert Table 7.23 about here]

Next, the linear regression results for the UBS CoCo are shown in Table 7.23 in the results appendix. Again, the government spread is the only statistically significant explanatory variable. The effect is -1.13 on the CoCo spread. Only 12 per cent of the spread is explained with the regression model according to the R^2.

7.2.4.5 Granger causality and linear regression results for Unicredit

[Insert Table 7.17 about here]

For the Granger causality analysis for Unicredit, compare Table 7.17 in the results appendix. In contrast to the other banks in the sample the H(0) of Q1 is rejected for the VAR(1), therefore suggesting that stock returns in period *t* Granger-cause the CoCo spreads of Unicredit in period *t+1*. Also the BIC of this model is the smallest of all auto vector regressions.

For Q2 and Q3 the H(0) is not rejected for the VAR(1), which has the lowest BIC. This means that the equity market volatility in general does not Granger-cause Unicredit's CoCo spreads. Also, the bank's CoCo spread does not Granger-causes Unicredit's stock returns volatility. However, the VAR(3) of Q3 suggests that the CoCo spread Granger-causes the stock returns. Yet the BIC of this model is larger than the BIC of the VAR(1), so evidence speaks against using the VAR(3). So, in conclusion, the empirical analysis suggests a one-directional relationship of the first lag of Unicredit's stock returns on the CoCo spreads.

[Insert Table 7.24 about here]

Next, the linear regression results for the Unicredit CoCo are shown in Table 7.24 in the results appendix. The Government bond spread, as for all other banks, is relevant in terms of explanatory power and accumulates to an effect of -1.81. However, the regression model explains only 16 per cent of the CoCo spreads.

7.2.4.6 Granger causality results of the bond indices and equity market

All five banks in the sample are tested for Granger-causality on their individual stock returns and CoCo spreads. In addition to investigating these micro-level causalities, performing the Granger-causality test on a macro-level give a rounded image. So the causality between the equity market and bond market in general is analysed to derive a possible directionality. First, this is done for the Euro Stoxx Europe 600 and IBOXX Corp. Bond index to answer question Q4, and vice versa in Q5; second, this is done for the Euro Stoxx Europe 600 and IBOXX Corp. Bond for Banks only index in Q6, and vice versa in Q7.

[Insert Table 7.18 about here]

For the Granger causality analyses for the corporate bond index compare Table 7.18 in the results appendix. The H(0) is not rejected for any of the lagged models for Q4, suggesting that the market volatility does not Granger-cause the index of all corporation bonds. However, the H(0) is rejected for Q5 in the VAR(1) model. Since this model has the lowest BIC, this suggests that the corporate bond index spread Granger-causes the market volatility.

[Insert Table 7.19 about here]

For the Granger causality analysis for the bank bond index compare Table 7.19 in the results appendix. The H(0) is not rejected for any of the lagged models for Q6, suggesting that the market volatility does not Granger-cause the index of the bank bonds spread. However, the H(0) is rejected for Q7 in the VAR (1) and VAR(4), suggesting that the bank bond index spreads Granger-cause equity market volatility. Since the 1st lag model has the lower BIC, there is strong evidence against the VAR(4) model and the suggested causality. In the aftermath of the global financial crisis of 2008 and the economic crisis in Europe, the one-directionality is not a surprise. The banks, as central element of financial markets, can cause equity markets to move as a direct result because of fears of resurgence of financial distress or even a crisis in Europe. Also, compare this with the systemic risk results in chapter 5. There, the ΔCoVaR for post-crisi banks is consistenly higher than before.

The application of the linear regression model on the bond index and the bank bond index show a similar picture. An increase in the spread of one unit has a negative effect on the two bond indices as expected. For both, the government bond spread is of statistical significance and explains 36 per cent and 26 per cent of the spreads, see Table 7.25 and Table 7.26, respectively.

7.2.5 Conclusion and outlook

In conclusion it appears that the alternative risk-free investment opportunity, i.e. the German 10 year benchmark bond, is the main driver for the observable CoCo bond spreads. Only for Unicredit the own stock returns volatility directly affect the CoCo spread. This explains the large spike in the CoCo spread – not the change of the spread – in late 2011, see Figure 7.6. However, compared to bonds in general – and also bank bonds – the CoCos here behave in different ways. The existing CoCos differ substantially in their terms of conversion. The threat of touching the trigger event has not yet occurred in the data set. Nevertheless the fact that such a trigger exists is reason for concern to the investors. This is suggested by the theory presented in the previous chapter and could not be dismissed by the empirical findings in this chapter.

Recall the example of Deutsche Bank from the introduction. This case is anecdotal evidence that information regarding a bank's CoCos can have immediate impact on the bank's stock price. However, this could not be confirmed with the empirical results. This is actually good news, because this suggests that there is no mutually reinforcing feedback loop of declining stock returns – carrying information about a decline in the bank's health – causing volatility of CoCos because of fear of conversion, and then again causing stocks to further decline, or become more volatile for that matter, because share prices now *receive* information about the health of a bank from observing the volatility of the bank's CoCos.

Surprisingly, over the whole period from mid-2010 to 2015 the stock returns explain the CoCo spread of Unicredit. This effect cannot be identified for the other banks. In comparison to UBS the summary statistics for the stock returns and CoCo spreads do not differ greatly. Also, the terms of UBS' and Unicredit's CoCos are almost identical. Unicredit pays a slightly higher coupon.

However, comparing the results from the empirical CoCo analysis with the systemic risk ranking according to the ΔCoVaR methodology used in chapter 5 give interesting suggestions. Recall Table 5.1. The results suggest that Unicredit's CoCo spread is caused by its stock returns volatility, at the same time it is the systemically most relevant bank in the same observation period. Here is a crucial difference between UBS and Unicredit. Unicredit was systemically relevant well before the observation period for the CoCos began, ranking 10th pre-crisis, 5th during the crisis, and 2nd post-crisis. The other banks in the sample rank much lower in the post crisis period. UBS was ranked just behind Unicredit, i.e. 11th, in 2002 to 2006, but migrated to 15th and 21st during the crisis in 2007 to 2009 and 2010 to 2014, respectively. Taking the systemic risk results at face value, this suggests that the two banks deviated in terms of systemic risk contributions and that is captured in the relationship of systemic risk and CoCo spreads; Unicredit remains a concern over the full period, UBS less so.

In general, the results suggest that no clear impact of a CoCo can be derived *ex ante*. This is important for CoCo-issuing banks and markets alike and requires caution when marketing such debt claims. Also this is important for policy makers. The intention behind CoCos in the first place was to make banks safer and introduce a contingency for distress, yet the existence of feedback effects cannot be eliminated with CoCos in their current form.

However, from a macro-prudential point of view, how are CoCos useful for a regulatory agency to promote its regulatory objective of maintaining financial stability? The CoCos that are currently in the markets do not exercise macro-prudence as defined in this PhD thesis in the two research questions: First, does the topic at hand incentivise banks to abstain from unsustainable business practice, therefore to a degree not creating systemic risk? Second, does the topic at hand – here CoCos – contain systemic risk as systemic risk materialises? In the current form the existing CoCos can strengthen the capital base of banks since after the trigger event the leverage is decreased. Banks have no immediate access to this capital since it is contingent. However, the high coupon payments are substantial and impose a penalty on the liquidity situation of the issuing bank.

The next section proposes debt-to-equity CoCos for the purpose of a recovery or resolution of banks. These are envisioned as a permanent penalty on bank managers instead of CoCo investors like the write-down CoCos of this chapter's sample suggest.

7.3 Proposal for CoCo: a recovery and resolution tool with build-in market discipline

The motivation behind this section's CoCo proposal is to issue debt that is the first tranche to be converted into equity after incumbent equity capital is not quite exhausted, but too little to reassure a bank's health. A credible CoCo design would make depositors, who are a quasi-creditors, more reassured that their deposits are unaffected by the financial disruption the bank faces. Hence, CoCos need to be embedded in the discussion about macro-prudence. The aim of this section is to design CoCos to first, decrease the creation of systemic risk on the micro-level, i.e. the individual bank. In more general terms the building up of systemic risk must be reduced. Second, a non-orderly bankruptcy of a sufficiently big bank can cause systemic concerns. So, in addition to disciplining a bank CoCos can be featured in an orderly resolution or restructuring of a bank. This is another point not emphasised enough in the existing literature.

The previous chapter 6 distinguishes bail-in capital from contingent convertibles (CoCos). Both are contingent capital. While the trigger event of the former is subject to a decision made by a regulatory agency, the latter is a private contract to either convert debt into equity or write-down upon a pre-defined trigger event. The first advantage of CoCos over bail-in capital is that the conversion is an automated mechanism that saves time in the process of de-leveraging a struggling bank. The second advantage is that investors can estimate the probability of the trigger event. Unlike CoCos the discretion of a regulatory agency introduces an element of uncertainty to markets; exactly something that can exacerbate system wide distress. This section focuses on debt-to-equity CoCos.

Two problems arise: First, it is arguable why an investor should swap his debt claim into new equity that is a residual claim of a seriously struggling bank. This would not be a good deal. Second, the automatic mechanism to convert debt into equity is de facto a second chance for the bank to avoid bankruptcy.

As for the first problem of creating a good deal to investors, it is quite possible that the need for further write-downs due to declining asset prices exceeds incumbent equity and the newly converted equity. A gone-concern bank can cause a total loss of the CoCo investor's wealth after conversion. The alternative is to hold straight debt of the bank. In case of a bankruptcy the investors can still negotiate the hair-cuts on their debt claim. They face a loss on some of their wealth and not a total loss as in the case of a gone-concern CoCo conversion. So in order to make CoCos marketable, investors must be offered a good deal. This can be done by designing CoCos on a going-concern basis, so the bank's business can be continued. This means that conversion is triggered well above a possible bankruptcy. The new equity has still an intrinsic value that makes conversion still a good deal.

As for the second problem of granting a struggling bank a second chance, the conversion would immediately prop up a bank's equity to avoid an imminent bankruptcy that could destabilise the financial system. Creditors would automatically become shareholders, as stipulated by the majority of CoCo-related literature. Now suppose that an otherwise gone-concern bank is pushed back to a going-concern level because of the conversion of CoCos. New equity is available and raises the capital level. Shortly after, the equity could be reduced to pre-conversion levels and new CoCos are issued. If this becomes a frequent routine it, this keeps alive a bank that is not healthy on its own but is artificially propped up if its distressed state poses a threat to the financial stability objective. This routine would eliminate the threat of a bankruptcy; this is not highlighted enough in the related literature. The new owners can be still sceptical how to deal with their new investment of a bank that is not healthy (see Calello and Ervin, 2010).

The related literature does not give specific recommendations about what should happen after CoCo conversion. The bank benefits from de-leveraging and produces more loss-absorbing equity capital. But should new CoCos be issued immediately after? Should they be issued with a delay? Should new CoCos be issued at all? The incentives of bank managers, shareholders, and CoCo investors are not only determined by the terms of conversion exactly in the moment the trigger is pulled; the wealth of the particular group is also affected post-conversion and therefore shapes the pre-conversion incentives. This section gives a comprehensive analysis that also proposes how the time after CoCo conversion should be used to recover or resolve banks.

The bank's management have the ultimate decision about, and so responsibility for, the institution's risk strategy. Hence, if sustainable risk taking is agreed upon on the top level, concerns of systemic risk can be reduced. To achieve this, the management must face the consequences of their decisions before they become a concern to depositors and other creditors. This reinforces the argument to design CoCos on a going-concern basis. The moral hazard of managers must be circumvented so the bank can avoid serious self-made disasters in the first place. Again, concerns of destabilising the financial system are bigger if it is a systemically relevant bank because of its sheer size or interconnectedness.

In this chapter the aim of CoCos is to disentangle the particular incentives of bank managers, shareholders, and creditors on a timely basis. This can be done with specific features that differ from the existing proposals: Re-installing a clear order of loss-absorbency of different groups of investors. Shareholders must be fully responsible for absorbing losses, meaning experiencing a loss of wealth before any other group of creditors, including CoCo investors. Making CoCo investors “contingent” shareholders distorts the natural order of rewards for taken risks. This means that loss-absorbing equity by definition has a higher risk than straight debt and therefore is repaid with a higher reward in the form of a residual claim on the bank’s profits. The rewards on straight debt are limited to contractually agreed coupon payments. On the other hand the risk attached to straight debt is less sensitive to the profits of the bank. It only becomes sensitive if the bank becomes insolvent.

7.3.1 Choosing a robust trigger event

This sub-section discusses the choice of the trigger event for the proposed CoCo design. A preference for an accounting trigger based on book values (for example Glasserman and Nouri, 2010) in the earliest CoCo proposals may partly be due to the then fresh experiences with distorted markets during the financial crisis. For example, CoCos are converted when core equity Tier 1 falls to 7 per cent. Other authors see a trigger based on a ratio of two variables, for example market-priced equity to assets, better suited than a one-dimensional trigger (Flannery, 2002; Duffie, 2009). As soon as it falls to a pre-defined level that indicates that a bank has too little equity, CoCos are converted.

One concern is that short-selling could cause temporary disruptions. If the trigger is linked to market values a conversion may be premature. CoCo investors could short the banks stocks, the intended decline in stock prices would hit the trigger and these investors’ strategy would be rewarded with undervalued shares that would rise to the initial fair value. In addition, a dilution of incumbent shareholders after conversion can cause a downward spiral since the low stock prices may lead shareholders to liquidate any pecuniary interests in banks and so the share price would decline further. De Spiegeleer and Schoutens (2013) show this sensitivity of equity to CoCo conversion. The problem is that CoCo investors, who receive equity for their debt claim, have to hedge the bank’s shares. Because of this the share price is further decreased. The authors propose to reduce this problem by making CoCos subject to multiple triggers.

However, defenders of a market-based trigger point out that accounting measures allow the banks to influence the trigger event and furthermore, per definition, book values are mere historic values and of no particular value for the financial markets (Goodhart, 2010; Calomiris and Herring, 2011). For these two reasons, the trigger event may occur only when the bank is already in distress and therefore the purpose of CoCos to timely reinforce the bank's financial stability is not met. Market values deliver more timely indicators for the health of a bank and in contrast to book values also comprise of information about off-balance items (Flannery, 2009). This view is also reinforced by the new Basel III requirements that stipulate to reintroduce information on off-balance sheet operations like special purpose vehicles and consecutive derivative instruments, which played a major role in the recent crisis (Basel BCBS, 2010b), see also chapter 2.

A market-based trigger is more likely to reflect the stability of a bank. However, this requires that the markets have a clear account about the overall state of the financial world. If there are widespread panics in the markets there is little reason to believe that the current market price reflects the bank's true value. Recall the difficulties Northern Rock faced in refinancing through money markets during the decline of mortgage-backed securities. Despite good quality of the mortgages the bank wanted to borrow against, the financial markets refused to lend against anything mortgage-related. Such a discrepancy between the fundamental factors and market perception is the main problem of market-based CoCo triggers, especially during episodes of unrest (Perotti and Flannery, 2011). So, a negative verdict reflected in a low share price that is not justified by the fundamentals, can trigger an unnecessary conversion.

On the other hand, an overoptimistic market perception about banks across the board could mean that a single bank's mismanagement goes unnoticed. This difficulty in choosing the trigger resembles what in the field of statistics is known as type I error and type II error of hypothesis testing, see for example Sheskin (2004). The type I error means that a hypothesis turns out to be true but is rejected; the type II error means that a hypothesis turns out to be false but is not rejected. Suppose the hypothesis is that a bank is stable. The trigger is hit and causes the conversion of CoCos, even though the bank does not need them. This is a type I error. Alternatively, the hypothesis is invalid, the bank is not stable. The trigger is not hit and does not cause the conversion of CoCos, even though the bank is in need of conversion. This is a type II error. The costs of a type II error are higher than those of a type I error. It would defeat their own purpose if CoCos are not triggered when in fact their conversion can improve financial stability. There would be no point in introducing them as a macro-prudential tool.

In conclusion, the kind of the trigger decides whether CoCos can deliver the regulatory purpose to mitigate losses to a bank and reduce the threat of contagion in the banking sector. It is doubtful whether a purely accounting-based trigger, for example book value of assets, has any valuable information that indicates the bank's chances to survive financial distress. The trigger must carry unambiguous information because these matter for market participants to create an opinion about the future. Market-orientated triggers are generally able to provide for this.

A market-based trigger such as share price is supposed to carry relevant information about bankruptcy. Lower levels, i.e. low share price, suggest that the equity of a bank is not attractive to markets and suggest that the bank is performing poorly. Equity will have its lowest market price close to the bankruptcy threshold. However, bankruptcy or financial distress in general is foreshadowed by a decline in equity price in the weeks before bankruptcy procedures have officially been announced by regulatory agencies. Obviously, if the trigger level is too low, CoCos are obsolete because bankruptcy occurs anyway. With higher values of the trigger conversion occurs well before the bankruptcy threshold of the bank. This increases the capital cushion of the bank before serious financial distress could become contagious and a systemic crisis evolves. Some authors analyse the potential of CoCos assuming that the current share price level serves as the trigger event (McDonald, 2011; Sundaresan and Wang, 2010). This point in time trigger is exposed to manipulation. In addition CoCos can be converted accidentally if the share price fluctuates. This leads to endogeneity of the trigger and the valuation of the bank’s equity. Sundaresan and Wang (2010) show how this leads to the problem of multiple equilibria. Similarly De Spiegeleer and Schoutens (2013) show how sensitive equity is to CoCo conversion and that by hedging this risk CoCo conversion can further drive down equity prices.

In order to make the trigger robust, the quasi market value of equity ratio (QMVER) (Calomiris and Herring, 2011) delivers a good starting point. In addition, this variable is measured over a period of time, say 90 days. First, the costs of manipulation are prohibitively high. Second, type I errors are avoided. A likely volatility of the bank’s share price in times of systemic distress – not yet a systemic crisis – does not prematurely trigger conversion. In more general terms, the market value of the equity ratio at time *t* is defined as:

$$\frac{Equity_t^{MV}}{Equity_t^{MV} + Debt_t^{MV}} \tag{7.12}$$

The market value of equity in relation to debt delivers an assessment of the health of a bank (see also Glasserman and Nouri, 2010). The total value of the equity is the sum of all shares valued at the current share price, this is also called market capitalisation. The debt in the formula gives a point of reference to put the market capitalisation into context. However, Calomiris and Herring (2011) point out that calculating the market value of debt can be costly. Not all debt positions are traded in the financial markets. The difference to the nominal or book value is not big anyway, hence the "quasi" in QMVER. They propose just to use the book value so that:

$$\frac{Equity_t^{MV}}{Equity_t^{MV}+Debt_t^{BV}} \tag{7.13}$$

This measure alone allows for triggering conversion of CoCos due to either market manipulation or simply a sudden one-off shock in the stock markets. This can be avoided by taking the average of that ratio over a period of a 90 day rolling window.

There is a trade-off between a "point in time" accuracy, or timeliness, of the trigger and the measurement of it over a specific period. The first indicates the trigger's timeliness in the short-run. The current share price of a bank is such a short-run measure. The price is determined by market perception on an inter-day basis and can jump considerably. As indicated above, this might not be an appropriate measure during financial distress when prices are exposed to high volatility. Ultimately such a measure would be a trigger that converts CoCos prematurely.

Second, a long-run perspective of the movement of the ratio is more reliable than a point in time observation. A conversion occurs if the average of this ratio over a certain period, say 90 days, touches the predefined trigger. This means that the bank's management failed to make clear that the overall strategy for the business is sound. Yet, the difficulty is to determine whether an immediate downward movement marks, in retrospective, the first signal of a decline in health.

In conclusion there is a trade-off between timeliness and reliability. Recall that the purpose of CoCos is to be converted in order to increase the stability of a bank. A sudden drop of the market value of the trigger does not necessarily reflect that the bank is indeed in distress. Yet, a persistent downward movement over time can lead to this conclusion. Nevertheless, a moving average trigger is robust against volatility that is likely to be observed in times of systemic distress.

7.3.2 Conversion into equity with an exclusive call option for incumbent shareholders

This sub-section proposes an exclusive call option for the new equity as the terms of CoCo conversion. Generally speaking, a call option gives an investor the right, not the obligation, to convert his debt claim into equity. This is option is expected to be exercised if the investor can increase his wealth, i.e. the equity has a higher value than the original debt claim. Doing so changes the incentive structure of CoCo investors, shareholders, and bank managers. These are subject of the following sub-sections.

A trigger that cannot be manipulated is crucial to the credibility of CoCos as a macro-prudential tool. Furthermore financial markets' acceptance is increased. A conversion must not be confused with an actual or reasonably expected bankruptcy of the bank. In order to promote financial stability, this CoCo proposal disentangles the worst case scenarios upom a bankruptcy for all involved stakeholders, i.e. bank managers, shareholders, depositors, and other creditors.

The individual worst case scenarios are the following: Bank managers must admit their mismanagement that potentially damages their reputation, shareholders see their investment wiped out, other debt holders are worried about whether they are bailed-in in the form of a haircut on their claims, and depositors start a run on their savings despite deposit protection being in place (Iyer and Puri, 2008). Especially the latter is mostly a product of the previous two events if they make it into the headline news. Again, compare this to the leaked information about possible government aid for Northern Rock.

This threat to the bank's survival can come with social costs in the form of a bank run on the deposits that can spread to other banks. In the worst case financial intermediation is disrupted and lending to the real economy is decreased. Alternatively social costs occur when this systemic risk is countered with financial support by the public in the form of taxpayers' money.

A call option on the new equity after CoCo conversion must first be made available to incumbent shareholders (Pennacchi *et al*., 2011). CoCo investors should not be made "contingent" shareholders that become permanent shareholders upon conversion as careful reading of the related literature suggests. Instead once the trigger event occurs, the new equity is offered exclusively to incumbent shareholders. They are offered the new equity at a discount, meaning that they can buy this new equity cheaper than the current share price. The consensus in the literature (chapter 6) is that a distribution of wealth between CoCo investors and shareholders is a source of concern for pricing such financial instruments. The proposed exclusive call option deliberately exploits this as a feature. According to the contractual terms, debt converts into equity not *at par* but at a premium for the CoCo investors, i.e. they would receive more equity than their CoCo is worth in nominal terms. This also means that incumbent shareholders would be significantly diluted. However, at this point the pricing issue (Sundaresang Wang, 2010) is circumvented in the following way: Incumbent shareholders are exclusively offered the purchasing right for this new equity at a lower price than the current market price. The amount of new shares times this exercising price must equal the nominal value of the CoCo so that as a result CoCo investors are paid out with cash at par; they neither suffer a decrease in wealth nor do they increase their wealth with deliberately seeking conversion.

When incumbent shareholders buy the new equity from CoCo investors, they increase their influence in the bank and can use their “countervailing voting constituency” (Coffee, 2010, p. 10) to replace the management. Here a crucial differentiation must be made: Coffee assumes that CoCo investors are more risk averse than incumbent shareholders. After conversion the additional risk-averse shareholders counter risk-tolerant incumbent shareholders. This chapter’s proposal concurs with the idea to manipulate voting constituency to enforce a change of the bank’s strategy. However, this is done so *not* by making the group of shareholders larger, more heterogeneous and fragmented, but more homogeneous and concentrated.

CoCos now are designed in a way so that the bank managers do not see a bankruptcy as the ultimate threat to their career, but the conversion of CoCos. From a macro-prudential policy point of view, the higher – or the more prudent – this conversion threshold is above the bankruptcy threshold, the earlier the bank management will take action to avoid hitting the trigger in the first place. Suppose that the trigger event is reached at the 8 per cent equity ratio Basel III stipulates. The bank’s management may decide to keep equity at, say 9 per cent all the time.

Also, investors who are themselves subject to capital requirements like other banks, pension funds, etc., are not exempted from purchasing CoCos because they do not keep the new equity upon conversion. Nevertheless they should be part of the design process and broker these instruments (Kashyap *et al*., 2008). This avoids the market for CoCos becoming a mere niche.

The following sub-sections analyse the different groups incentives under a CoCo proposal that stipulates that CoCo investors convert debt to equity and the incentives if incumbent shareholders have the exclusive option to buy the new equity from CoCo investors.

7.3.3 Incentives for CoCo investors

This sub-section demonstrates how the call option manipulates the incentives of CoCo investors. Recall from the literature review in chapter 6 that originally CoCo investors are expected to sacrifice a fixed coupon-yielding debt claim for equity that is only entitled to the residual profits of a bank. This would seem a particularly bad a deal for two reasons.

First, if a low-trigger CoCo approximates a bankruptcy threshold CoCo investors receive shares of an already struggling bank. This is not attractive to risk-averse investors such as pension funds that might not be allowed to hold equity of other financial institutions. From a macro-prudential perspective if the bank is systemically relevant conversion of CoCos can introduce financial distress to the other investing institution. This contagion must be avoided.

Second, even a high-trigger level as proposed in this chapter does not change the fact that creditors become shareholders. The value of such a CoCo is not only the discounted coupon payments until maturity of this bond. In addition, CoCo investors must address the possibility of receiving shares. This requires an evaluation of the bank like other incumbent shareholders do. This increase in monitoring costs must be reflected in the pre-conversion coupon payment. Then again, it is arguable why an investor should go through the same effort as other shareholders but not benefit from the theoretically unlimited upward potential of equity returns. Of course, if the particular CoCo investor also happens to be a shareholder, then there is no duplication of these monitoring costs. If not, other potential CoCo investors would not invest in CoCos and the market for CoCos would mainly consist of investors that already are shareholders.

Those investors, that hope to obtain equity that could be undervalued, would be willing to buy CoCos. However, this again suggests that investors already went through the process of evaluating the bank and know that the bank’s equity at conversion is undervalued. The easier alternative is to buy the existing shares in the markets and there is no need for obtaining it indirectly.

One possible scenario why this might still be possible is a long-term motive for holding shares: it is not primarily for short-term financial gain in the form of dividends and increasing share price. Instead, investors aim to build up an ownership position in the bank and its asset portfolio. If the trigger is the share price, the CoCo investor has the incentive to manipulate the price through, for instance, short selling to trigger the conversion, just to see the share price climbing back after they received the new shares. For reasons of avoiding manipulation a moving average trigger such as the QMVER is better suited.

The introduction of a call option to incumbent shareholders makes the CoCo investors' need to evaluate the bank's equity unnecessary. The burden of monitoring costs is shifted to shareholders. Upon conversion incumbent shareholders buy the new equity – their incentives are discussed in the next section – for a value that equals the nominal value of the CoCo bond. So at all times it is clear to CoCo investors that their financial exposure to the bank ends with conversion. They collect the last coupon payment and sell the CoCo at the nominal value exclusively to incumbent shareholders.

This clear, pre-defined exit route for CoCo investors decreases the costs of CoCos and opens this financial instrument to all market participants. Institutional investors and other systemically banks can hold CoCos. The call option abates the threat of contagion. In contrast to other proposals that make CoCo investors permanent shareholders, here the call option buys them out of the bank.

7.3.4 Incentives for incumbent shareholders

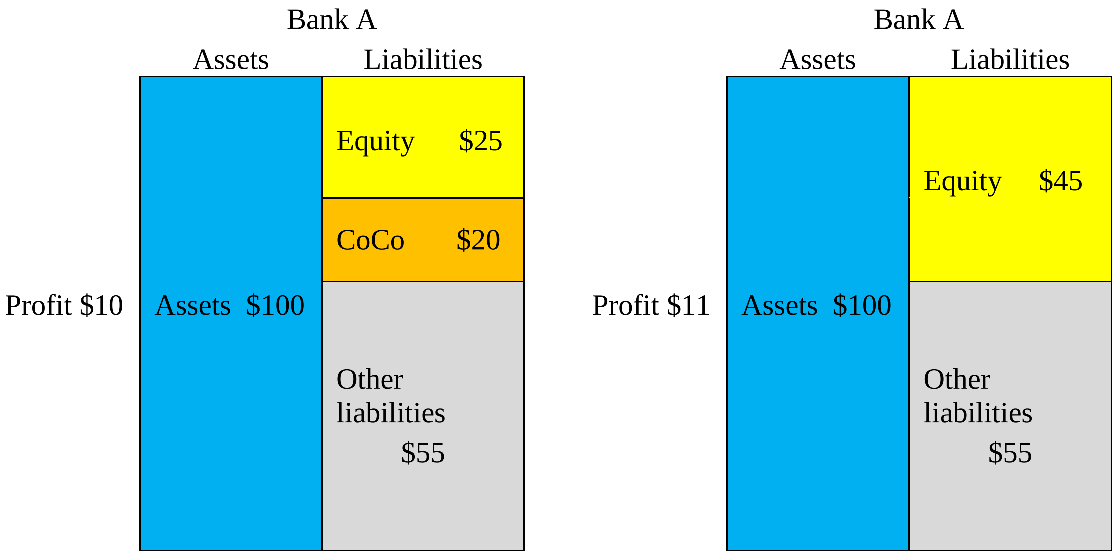
This sub-section analyses how the incentives of shareholders – excluding bank managers – are manipulated by the introduction of a call option on the post-conversion equity. Conversion happens upon a high trigger when a bank is financially destabilised, yet not facing bankruptcy and remains going-concern. Without CoCos shareholders have a moral hazard incentive to increase the riskiness of the firm, see Myers (1984). They decrease the value of the bank in the form of higher default risk. As long as the decline of the overall bank value is smaller than the decline of the value of the debt, relative wealth is channelled to shareholders. In analogy, when eventually a default is threatening the survival of the bank this incentive to shareholders remains. They refuse to inject more equity to stabilise the bank – and avoid a total loss of their own share – because the immediate effect is that other debt holders are paid first. This debt overhang problem can be overcome with CoCos.

It is crucial that CoCos are designed to disentangle these interlaced incentives. An automated conversion decreases the debt burden and increases the equity cushion. Again, other debt claims are increasingly reassured because the coupon payments on CoCos disappear. The value of the bank is increased because mandatory conversion avoids the debt overhang problem. The higher, and therefore the more prudent, the trigger level the higher is this reassurance. This in return would decrease non-CoCo creditors' incentive to monitor the risk strategy of the bank.

The following numerical example illustrates the different effects, see Figure 7.7. Suppose that Bank A has assets worth $100 and returns $10 after interest on all debt is paid, the equity capital of $25 consists of five shares, CoCos worth $20 and $55 other debt. Given the call option enhancement CoCo investors do not need to consider the credit risk of the bank. Suppose that the CoCo coupon is 5 per cent per annum.

Each share is worth $5. Furthermore assume that all profits are distributed to shareholders so that each share claims 20 per cent of the profits, i.e. $2. As for voting rights each of the five shares has a 5 per cent share in the total assets of $100.

Figure 7.7: CoCo conversion with a call option. Source: Own illustration.



Now suppose that a high-level trigger is touched, meaning that the bank faces some distress but is well above the bankruptcy threshold. Of course, in order to reach the trigger event, capital has decreased before. Value corrections on assets are reflected in the loss-absorbency of equity. So the assets might have been worth $105 and equity worth $30; so each share's fair value would be $6. However, the purpose of this numerical example is to illustrate what happens in the *exact moment* of CoCo conversion.

In the moment of conversion, the book value of the shares is $5. Assuming that the shares are traded at that value[18], all outstanding CoCo bonds are converted into $\frac{\$20}{\$5} = 4$ new shares. Now 9 shares with $5 accumulate to a $45 equity cushion, immediately boosting the equity capital ratio from 25 per cent to 45 per cent.

After conversion additional equity immediately decreases the return on existing equity. A counteracting effect is that the 5 per cent coupons on CoCos are saved and *ceteris paribus* are available to all shareholders. So the profits immediately increase to $\$10 + 0.05 \times \$20 = \$11$. On the other hand incumbent shareholders are diluted from their original return of $2 per share to $\frac{\$11}{9} = \$1.22$ per share. The total return on equity sharply drops from $\frac{\$10}{\$25} = 40$ per cent to $\frac{\$11}{\$45} = 24.44$ per cent.

Incumbent shareholders are hit twice: the debt overhang problem is abated, but debt repayment is served before the shareholders receive dividends, and the newly issued equity claims a portion of the residual profits of the bank, hence diluting incumbent shareholders. In the long-run, equity investors would be wary of banks in general. Hence, raising equity would be more costly for banks in the first place because those investors willing to offer equity would ask for a higher premium on such. A high trigger increases the likelihood of a conversion and hence the dilution of shareholders even though the overall stability of the bank is increased.

Recall that among the incumbent shareholders there can be investors more prone to risk than the bank managers. The high risk profile of the bank is less due to the bank's management but the shareholder base demanding higher returns. With the conversion into equity the former CoCo investors become a "countervailing voting constituency" (Coffee, 2010, p. 10), assuming that those who buy CoCos are less risk prone. This takes pressure off the management to deliver return, especially in the form of taking unsustainable risks. Consequently, if it is clear that CoCo conversion would always heavily dilute incumbent shareholders, they would look for alternative investment opportunities. Investors who are moderate in their demand for returns are less deterred than risk prone investors. Moderate shareholders do not pressure bank managers to generate high returns. This moderation allows

[18] Normally, shares of healthy firms are traded above the book value. The fair market value of equity depends on the future profits of the firm that are discounted at a rate that also includes the riskiness of that future cash stream. Considering these facts this numerical example is a conservative estimation for illustrator purpose only. Assume a perpetual profit of 10 per cent and 10 per cent as an adequate discount for the riskiness of the bank: $10/0.10 = $100. $100 for $25 equity gives a return of $4 to each $1 equity. The book value of each share is $5 so the current fair market price per share is $20 per share.

for a more sustainable management of the bank well above the CoCo trigger. Again, because CoCo investors would have costs to assess the bank's equity before conversion, this would not be a good deal to CoCo investors.

However, back to the numerical example: Incumbent shareholders are now exclusively offered the purchasing right for the four new shares. Upon the equity-boosting conversion of CoCos, which steers the bank clear of more serious distress, shareholders are given the opportunity to avoid dilution. Suppose that a shareholder holds one share and now considers the next step: his share is still worth \$5 but his claim on the residual profits of the bank decreased from \$2 to \$1.22 or 20 per cent to 11.11 per cent, respectively. This is equivalent to a decrease of a return on investment of \$2 to his \$5 share to \$1.22 to his \$5 share or 40 per cent to 24.44 per cent. However, now he can exercise a call option on the four new shares. Suppose that all four new shares are bought at the current fair value of \$5 to pay the CoCo holders at par value. The shareholder only considers purchasing one of the shares at exactly \$5. If he does so he now has invested a total of \$10 and now receives \$1.22 per share or \$2.44 in total. This is a return on investment of 24.44 per cent compared to his previous 40 per cent figure. However, keep in mind that the bank dramatically increases its loss-absorbency with the conversion of CoCos and is now safer than pre-conversion. The shareholder held 20 per cent of a 25 per cent equity-financed bank, he now holds 22 per cent of a 45 per cent equity-financed bank.

The original idea of Coffee's countervailing voting constituency is not dismissed with the call option. Instead this chapter's proposal takes up his idea of harnessing a change in ownership structure in order to incentivise bank mangers to exercise due care. The individual shareholder has not only countered the dilution of his relative position in the bank but strengthened it. Suppose that not every incumbent shareholder has purchased the new equity. Those who have, gained influence in the ownership structure of the bank. The conversion is an opportunity to increase a strategic investment in a going-concern bank. Now, the shareholders can possibly reach a voting threshold that allows them to replace the existing management. This concentration of ownership power stays in contrast to Coffee's proposal. A more fragmented, heterogeneous shareholder base would hinder introducing change to a bank's management.

7.3.5 Incentives for bank managers

This sub-section demonstrates how the call option on the new post-conversion equity further curbs bank managers' appetite for short-termism. They must be incentivised towards sustainable risk-taking. Usually performance-based bonuses are measured in the maximisation of shareholder value which is defined as the return on investment of shareholders, i.e. return on equity. Macro-prudence aims at promoting financial stability. Both aims turn out to be diverging tasks. Nevertheless this CoCo proposal aims at internalising possible negative externalities of unsustainable risk-taking. So, CoCos can reconcile both tasks by setting incentives on the level where risk-taking decisions are made: the senior bank management.

The success of managers therefore should be re-defined as generating profits for shareholders *given* the macro-prudential aim of financial stability. Note that macro-prudence in this sense must not be seen as a constraint on the banking business but rather a feature that reassures other stakeholders' claims. Admati *et al*. (2013) challenge the prevailing maxim that financing banks with equity is costly hence leverage is paramount to a bank's profitability. For more details, see chapter 6. The authors conclude that more equity decreases the bankruptcy probability and the asked return on equity is decreased accordingly. Granted, profits may be lower, but systemic risk attached to these is decreased.

The previous section demonstrates how the call option for post-conversion equity can be a good deal for incumbent shareholders. The bank managers' performance can be measured by not converting CoCos.

The key element of this chapter's CoCo proposal is that conversion happens at a high-level trigger well above the bankruptcy threshold. This level resembles the new benchmark bank managers are judged by. The conversion of CoCos causes the return on equity to shareholders to decrease. Incumbent shareholders can avoid a dilution with exercising their call option and acquire the new shares. Not all shareholders avoid dilution and the ownership structure tends to result in a more concentrated shareholder base with increased voting rights. On the one hand shareholders have a decreased return on investment but on the other hand the return is safer and they gain more influence in the bank. This means that shareholders can remove bank managers and replace them with their choice of managers. Anticipating this scenario, bank managers have an incentive to moderate their investment decisions *ex ante*. In the end, it is in their personal interest to do so.

7.3.6 Post CoCo conversion is the first stage to an orderly resolution of a bank

This sub-section demonstrates how the proposed CoCo design can fit into the recovery and resolution of a struggling bank. Banks can still fail and this chapter argues that in fact those banks should be allowed to fail. Despite the new structure of financial regulatory agencies (chapter 3), and their macro-prudential toolkit (chapter 4), crises can still break out. There can be instances in which a bank that has been hit the hardest by developments in the financial system must be supported with state aid. Otherwise, in an attempt to survive distress the bank could liquidate vast amounts of its balance sheet. If it is a systemically relevant institution this could be the beginning of yet another series of fire sales. Consequently, even under the new macro-prudential paradigm central banks still play the role of "market-maker of last resort" in a crisis (Buiter and Sibert, 2008) and assist certain financial institutions and bolster the markets of affected assets in the financial system. There is a threat of a race for such aid. When distress in the financial system can become systemic, financial institutions load on even more risks in order to become systemically relevant and qualify for last resort measures.

Fortunately this CoCo proposal contributes to solving the conflict between the objectives of maintaining financial stability and allowing banks to fail. The link between these two is the moral hazard of banks that naturally arises when financial intermediation and thus the real economy must be protected. Putting down this protection in official writing in the form of the objective of financial stability makes this problem more severe. A macro-prudential policy maker must recognise and address the increased moral hazard.

The CoCo proposal does not stop right after conversion. Designing the period after conversion is an integral part of a CoCo proposal that is neglected by the literature. The proposal of Pennacchi *et al*. (2011) does not analyse the crucial time after conversion. So, in addition to making CoCos a good deal, second, a clear guideline for the bank through the crucial time after conversion is necessary and given in this chapter. This chapter extends their proposal accordingly. For example, should the bank issue new CoCos again? If so, bankruptcy could be postponed again and again. If not, the bank suffers exactly from the same moral hazard and systemic risk concerns CoCos ought to solve in the first place and there would be no point in introducing CoCos.

In addition two different effects determine the shareholders' wealth: The price effect and the volume effect. Share prices constantly move. After the conversion the market price of the bank's shares can go up if the increased loss-absorbency is received well by markets. On the other hand the market price can experience a negative correction. The bank is de-leveraged and consequently the return on equity decreases. Shareholders who received new shares additionally enjoy a volume effect since they now simply hold more shares. Depending on the size of the two effects wealth is either increased or decreased. Especially for this reason Sundaresang and Wang (2011) identify the pricing paradox as an inherent flaw of previous CoCo proposals.

Giving former CoCo holders new equity that is subject to re-evaluation, especially when the financial system as a whole is in a precarious state, unnecessarily introduces further distress. Instead, allowing incumbent shareholders to purchase the newly issued equity is a neat solution not only to avoid technical problems such as finding a pricing model.

More practically, the post-conversion ownership structure is a precursor to a possible resolution of the bank. The need for an intervention by public authorities is decreased for a private sector solution is already initiated. As the previous sections make clear upon the trigger event fewer individual shareholders hold more equity of the bank. The ownership structure is more concentrated after the conversion of CoCos.

What must be avoided is that in the long run a bank survives distress with the conversion of CoCos and issues new CoCos to survive the next disturbance. A constant repetition of conversion and issuance suggest that the bank is in fact not a healthy bank. This is a bank that continues operations but there is evidence that this is only due to benefiting external factors that keep a flawed business model running. For example, the monetary policy stance of central banks in the aftermath of the global financial crisis was to decrease interest rates to nearly zero to foster growth. Consequently those banks that are not competitive benefit from generous refinancing conditions close to zero per cent. This makes it more difficult to distinguish healthy from less healthy banks.

Now, further adjustments must be made to the CoCo design framework. It must cater for an orderly resolution of a bank. Rather than allowing the issuance of further CoCos immediately after conversion, there should be a period of probation that is also linked to certain requirements. This probation should be subject to the new ownership structure of the bank and, if applicable, the replacement of the bank's management. If there is no substantial change to either, a probation of, for example, one year would prohibit the issuance of new CoCos. During that period the bank must regain reputation among the markets and regulatory agencies.

Note that during such a probation the bank's management and shareholders are immediately exposed to the moral hazard and debt overhang problem again. This resembles a world in which CoCos does not exist in the first place. Hence a way has to be found to bridge this gap between two states of market discipline reinforced by outstanding CoCos.

Consequently the bank's management must be incentivised to work towards being allowed to issue CoCos again. It seems counterintuitive that the management issues a financial instrument that effectively puts them under shareholders' monitoring. It is true that after conversion the bank has a higher equity ratio compared to its competitors. However, the price bank managers paid was that shareholders now have more influence, hence constraining them in their plans for the bank and careers. In the long run, if CoCos are accepted by markets the conversion of such is perceived as proof of the managements' inability to enhance shareholder value. Thus, a conversion would translate to a loss of reputation which is the worst case for a manager.

One of these possible requirements during probation is to put the bank under close scrutiny by the regulatory agencies. This can include more frequent on-site visits to the bank and a closer engagement with senior management. Other constraints may be to link the CoCo probation to other regulatory tools such as limiting dividends to shareholders and retaining bonuses to senior staff (chapter 4). If the bank management satisfies the requirements they are rewarded with a regulatory dividend in the form of lifting these constraints. But they have to issue CoCos again. Of course, this only happens if the regulatory agency sees the bank fit. However, note that the regulator's pro-active scrutiny is replaced by shareholders' monitoring once again through CoCos.

In case the management fails to deliver at the end of probation, the regulatory agency can decide to engage with the shareholders and discuss replacing the management. If the decline in the bank's health is more severe the option of winding down the whole bank should be on the table. If so, a private sector solution to find other investors for the assets and liabilities should be initiated.

7.4 Conclusion and implications for promoting financial stability

CoCos according to this proposal are a "commitment device" to a bank's creditors. However, in contrast to existing proposals the commitment of incumbent shareholders is reinforced rather than asking CoCo investors to become shareholders of a bank. This indirect commitment is derived by incentivising incumbent shareholders to buy the newly issued equity into which CoCos are converted. The debt overhang problem stems from shareholders' reluctance to inject new equity when it is needed to increase firm value and avoiding bankruptcy. The more prudent the level of conversion is, the better a deal this is to shareholders. At the time of conversion they might lose some of their financial wealth. However, by exercising their right to buy the new equity they can abate the dilution of their relative position in the bank.

In the bigger picture from a macro-prudential regulation point of view it also introduces perverse incentives that can destabilise a bank. For example, if they were to keep the new equity CoCo investors might actively seek conversion. If they expect the market price of the bank's equity to go up, they have the incentive to temporarily manipulate the trigger event so that CoCos are converted. The trigger for conversion must capture distress on a timely basis, yet must not prematurely allow CoCos to convert. The quasi market value of equity ratio "QMVER" is such a trigger. It is not exposed to market manipulation or accounting manipulation, also known as window dressing, because it captures the equity value over a 90 days window. A manipulation of this trigger comes with costs that exceed the possible gains from obtaining undervalued equity.

Fortunately, these problems are circumvented with the introduction of a call option. Incumbent shareholders buy the new equity. CoCo investors are offered a clear exit option. The advantage is that they are bought out of the bank at par value of their CoCo bond with cash and no commitment to face a hair-cut on their debt claim. This makes CoCos available to risk-averse and institutional investors too.

After the exit of CoCo investors, the ownership structure of the bank is altered. The result of CoCo conversion is that the group of shareholders is not composed of a variety of different shareholders but is now more concentrated. Thus, individual shareholders tend to hold more power in terms of voting rights after conversion and so the management becomes easier to be removed. The introduction of a third group of investors – among shareholders and other debt holders – that exercises pressure on the management is not a necessity. In fact, more individual shareholders would compete for influence in the bank and hinder progress. Especially a bank in financial distress does not need such a competition among its shareholders.

CoCos are a micro-prudential tool for they immediately bolster the equity situation of a particular bank in distress. Recall the definition of the micro- and macro-prudential approach according to Borio (2003) in section 2.5. The link to the macro-prudential approach is that a bank is still allowed to fail but its non-viability is less a threat to the stability of the system as a whole. The conversion of CoCos, according to the proposal in this chapter, already introduces a path for the resolution of the bank and its assets that has not been in place during the last financial crisis.

Without CoCos managers should steer the bank clear of the bankruptcy threshold and the systemic risk problems around that threshold. Now, with CoCos managers have all the incentive to steer the bank clear of the CoCo conversion threshold. The bigger the difference between these thresholds, the more macro-prudent CoCos are. There is no severe violation of shareholder value maxim. The omnipresence of this “sword of Damocles” (Calomiris and Herring, 2011, p. 17) over the head of managers and shareholders is a constant reminder to refrain from taking unsound investments.

Nevertheless, it is worth pointing out that it requires the introduction of a financial instrument by macro-prudential policy makers to overcome the problems inherent to banking. Banks are not likely to voluntarily issue CoCos as a financial instrument that takes away their moral hazard. This chapter and the proposal outlined may serve as such a policy draft. Insofar, the introduction of CoCos to the banking sector does not impose yet another regulatory inconvenience banks have to abide by. Instead, it fosters market discipline that can “bring capitalism back into the heart of capitalism” (Tucker, 2011, p. 6), i.e. banks.

Bank managers in turn are under more scrutiny of shareholders. However, this pressure is not directed towards generating the highest possible profits but safeguarding the sustainability of profits. In contrast to the original proposals, CoCo investors see a clear exit route upon conversion. They are bought out of the bank by incumbent shareholders. Therefore CoCos are a relatively secure fixed income financial instrument.

As mentioned earlier in the introduction each chapter is set to address the two research questions identified in chapter 2. Therefore, the following dissucion aims to anser:

- Does this CoCo proposal encourage sustainable risk-taking?
- Does this CoCo proposal curb systemic risk when it materialises?

As for the first question, bank managers with foresight avoid the concentration of power of certain shareholders in order to protect their own gains. A specific shareholder could accumulate a considerable voting right majority after conversion and thus it is likely that changes to the management of the bank are introduced. Managers therefore steer the bank clear of the trigger event. In addition, a conversion threshold that is set well above the bankruptcy threshold reconciles the objectives of financial stability and the incentives of bank managers. They have an incentive to promote a sustainable investment strategy for the bank. However, this is not a mere lip service to promoting financial soundness for the sake of saving social costs. Instead, their personal wealth and career now depends on it. So, this CoCo proposal introduces the regulatory objective of maintaining financial stability to the shareholder value maxim in banks.

The proposal at hand also emphasises that shareholders face the constant threat of a “death by dilution” (Herring, 2010, p. 21) after conversion. Consequently increasing monitoring costs benefits their investment. From a social costs perspective this is a means of internalising negative externalities on the micro-level, i.e. the individual bank.

As for the second question, with this CoCo proposal the natural order of loss-absorbency is re-established: First, shareholders see the equity written down until the trigger event occurs. Then CoCo investors as subordinated debt holders exit the bank but do not suffer a financial loss. Shareholders exercise their call option for the new equity. The debt overhang problem is abated because they have the opportunity to acquire undervalued equity. Other creditors and depositors are unaffected. If the trigger is set to a prudent level, shareholders are incentivised to opt for a “good deal”. Despite a forced de-leveraging of the bank other creditors and depositors have no reason to panic and start a bank run.

In contrast to other CoCo proposals here the period after CoCo conversion follows a clear route. This helps deduce uncertainty to shareholders and CoCo investors. Furthermore the bank is put under public scrutiny. In a time of probation the bank is prohibited from prematurely issuing new CoCos. Shareholders who exercised the call option now benefit from a higher share in a de-leveraged, hence more stable bank. They can decide whether to replace those managers who did not avoid the conversion. New CoCos can be issued after the new shareholders agreed on a change in the bank’s business plan. During this process a comprehensive due diligence assessment of the bank’s business reveals whether it is worth to be continued (going-concern) or is resolved (gone-concern). This means that prior to a bankruptcy the private sector can compete for sound assets. If the result of this assessment is a going-concern bank, new CoCos must be issued. If the bank turns out to be a gone-concern, it is easier to negotiate a resolution with fewer shareholders who each have a relatively high share than with several, relatively small shareholders.

A further advantage of this CoCo proposal with an exclusive call option for post-conversion equity is that it does not put too high a financial burden on the bank in form of high coupon payments. One concern of CoCos is that post-conversion CoCo investors become permanent shareholders of a bank. If these investors happen to be systemically relevant financial institutions themselves, CoCos defeat their original purpose because they re-introduce systemic risk. A consequence would be to introduce holding restrictions to exclude certain institutions from investing in CoCos of other banks in order to avoid contagion.

Fortunately, because this chapter's CoCo proposal incorporates a call option for the newly issued equity to incumbent shareholders, no such restrictions are necessary. Regardless of what kind of investors they are, CoCo investors are bought out of the bank immediately after conversion. They do not become permanent shareholders. Even though there is an equity component in such a debt claim, fixed income investors and risk-averse institutional investors can invest in them (Herring, 2010). There is no discrimination of investors. Because of this simplicity, there can be a highly liquid market for CoCos in the future. So, CoCos can be made a macro-prudent tool and are not exposed to being a mere "accounting gimmick" (Goodhart, 2010a).

Results appendix B

Table 7.6: Augmented Dickey-Fuller test for Barclays

Lag	Change in CoCo spread	Critical value	Change in stock volatility	Critical value
AR(1)	-29.7614	-2.86	-33.5647	-2.86
AR(2)	-21.9949	-2.86	-27.2877	-2.86
AR(3)	-18.5953	-2.86	-23.3957	-2.86
AR(4)	-17.956	-2.86	-20.0729	-2.86
AR(5)	-14.6688	-2.86	-18.752	-2.86

Table 7.7: Augmented Dickey-Fuller test for Lloyds

Lag	Change in CoCo spread	Critical value	Change in stock volatility	Critical value
AR(1)	-31.9941	-2.86	-44.5334	-2.86
AR(2)	-27.1554	-2.86	-38.1995	-2.86
AR(3)	-22.0774	-2.86	-32.6127	-2.86
AR(4)	-16.9913	-2.86	-28.3739	-2.86
AR(5)	-14.6008	-2.86	-27.3062	-2.86

Table 7.8: Augmented Dickey-Fuller test for Credit Suisse

Lag	Change in CoCo spread	Critical value	Change in stock volatility	Critical value
AR(1)	-26.7348	-2.86	-33.6951	-2.86
AR(2)	-20.2252	-2.86	-27.6558	-2.86
AR(3)	-17.2905	-2.86	-23.0178	-2.86
AR(4)	-15.1492	-2.86	-20.2048	-2.86
AR(5)	-14.3697	-2.86	-19.1316	-2.86

Table 7.9: Augmented Dickey-Fuller test for UBS

Lag	Change in CoCo spread	Critical value	Change in stock volatility	Critical value
AR(1)	-28.5373	-2.86	-32.1275	-2.86
AR(2)	-21.7149	-2.86	-27.1354	-2.86
AR(3)	-18.5767	-2.86	-21.6567	-2.86
AR(4)	-16.2892	-2.86	-20.1207	-2.86
AR(5)	-14.821	-2.86	-17.9639	-2.86

Table 7.10: Augmented Dickey-Fuller test for Unicredit

Lag	Change in CoCo spread	Critical value	Change in stock volatility	Critical value
AR(1)	-26.5944	-2.86	-43.9334	-2.86
AR(2)	-24.172	-2.86	-34.9541	-2.86
AR(3)	-19.8325	-2.86	-31.1097	-2.86
AR(4)	-19.023	-2.86	-26.6365	-2.86
AR(5)	-16.4902	-2.86	-23.0957	-2.86

Table 7.11: Augmented Dicker-Fuller test for bond indices

Lag	IBOXX Euro Corp.	Critical value	IBOXX Euro Corp. Banks	Critical value
AR(1)	-21.522	-2.86	-21.2526	-2.86
AR(2)	-18.3515	-2.86	-18.4771	-2.86
AR(3)	-15.9011	-2.86	-15.6483	-2.86
AR(4)	-14.7365	-2.86	-14.5813	-2.86
AR(5)	-13.1241	-2.86	-12.9801	-2.86

Table 7.12: Augmented Dickey-Fuller test for explanatory variables

For the level of the explanatory variable, i.e. observation in period t.						
Lag	Equity market price	Critical value	Government bond spread	Critical value	Short-term refinancing	Critical value
AR(1)	-20.1671	-2.86	-2.2084	-2.86	0.7806	-2.86
AR(2)	-16.4431	-2.86	-2.0472	-2.86	0.4901	-2.86
AR(3)	-13.1394	-2.86	-2.0185	-2.86	0.2907	-2.86
AR(4)	-11.1207	-2.86	-2.0290	-2.86	0.1387	-2.86
AR(5)	-9.4470	-2.86	-2.0235	-2.86	0.0461	-2.86
For the 1^{st} difference of the explanatory variable, i.e. for $\ln(x_t) - \ln(x_{t-1})$.						
Lag	Equity market returns	Critical value	Government bond spread	Critical value	Short-term refinancing	Critical value
AR(1)	-44.3814	-2.86	-28.225	-2.86	-16.5469	-2.86
AR(2)	-37.9953	-2.86	-23.6512	-2.86	-13.1817	-2.86
AR(3)	-32.9589	-2.86	-19.3933	-2.86	-11.1569	-2.86
AR(4)	-30.5266	-2.86	-17.118	-2.86	-10.0005	-2.86
AR(5)	-27.9127	-2.86	-15.2065	-2.86	-9.0513	-2.86

Table 7.13: Granger causality test results Barclays

	Q1		Q2		Q3		all system
VAR(n)	LR 1	p-value 1	LR 2	p-value 2	LR 3	p-value 3	BIC
VAR(1)	1.1236	0.2891	0.0706	0.7905	0.2416	0.623	-28744.42
VAR(2)	0.0053	0.942	0.3855	0.5347	0.2664	0.6058	-28111.15
VAR(3)	0.0788	0.7789	0.8275	0.363	0.0212	0.8841	-28074.34
VAR(4)	0.2025	0.6527	1.2001	0.2733	2.7005	0.1003	-28079.74
VAR(5)	0.0776	0.7806	0.2352	0.6277	8.8213	0.003	-28068.04

Table 7.14: Granger causality test results Lloyds

	Q1		Q2		Q3		all system
VAR(n)	LR 1	p-value 1	LR 2	p-value 2	LR 3	p-value 3	BIC
VAR(1)	1.9394	0.1637	0.4743	0.491	0.1949	0.6589	-54541.44
VAR(2)	0.5211	0.4704	0.4429	0.5057	0.5421	0.4616	-53411.20
VAR(3)	0.1677	0.6822	1.6283	0.2019	1.0102	0.3148	-53380.33
VAR(4)	0.2572	0.6121	0.0423	0.8371	5.1489	0.0233	-53349.07
VAR(5)	0.0208	0.8853	1.9712	0.1603	6.6175	0.0101	-53342.48

Table 7.15: Granger causality test results Credit Suisse

	Q1		Q2		Q3		all system
VAR(n)	LR 1	p-value 1	LR 2	p-value 2	LR 3	p-value 3	BIC
VAR(1)	0.6719	0.4124	0.0218	0.8826	0.5839	0.4448	-31580.4312
VAR(2)	1.0645	0.3022	2.6292	0.1049	1.5395	0.2147	-30903.396
VAR(3)	4.9734	0.0257	7.7819	0.0053	0.6142	0.4332	-30866.4861
VAR(4)	2.6548	0.1032	5.8994	0.0151	1.6996	0.1923	-30877.7485
VAR(5)	0.7653	0.3817	4.1868	0.0407	1.1956	0.2742	-30846.9387

Table 7.16: Granger causality test results UBS

	Q1		Q2		Q3		all system
VAR(n)	LR 1	p-value 1	LR 2	p-value 2	LR 3	p-value 3	BIC
VAR(1)	0.1719	0.6784	0.2109	0.646	3.0544	0.0805	-30530.2481
VAR(2)	0.0558	0.8133	0.1356	0.7127	4.4134	0.0357	-29860.1071
VAR(3)	0.5995	0.4388	1.5961	0.2065	0.1163	0.7331	-29840.25
VAR(4)	0.082	0.7745	5.8245	0.0158	0.6884	0.4067	-29855.9193
VAR(5)	0.5627	0.4532	1.1903	0.2753	5.273	0.0217	-29823.6471

Table 7.17: Granger causality test results Unicredit

	Q1		Q2		Q3		all system
VAR(n)	LR 1	p-value 1	LR 2	p-value 2	LR 3	p-value 3	BIC
VAR(1)	10.8538	0.001	0.0279	0.8674	2.3035	0.1291	-50844.4705
VAR(2)	2.3251	0.1273	0.0296	0.8633	0.4617	0.4968	-49662.4621
VAR(3)	0.0516	0.8203	0.1216	0.7273	3.9888	0.0458	-49694.6357
VAR(4)	1.0729	0.3003	0.092	0.7617	0.2243	0.6358	-49651.2331
VAR(5)	0.5189	0.4713	0.2238	0.6362	0.511	0.4747	-49600.3415

Table 7.18: Granger causality test results all bond index

	Q4		Q5		all system
VAR(n)	LR 1	p-value 1	LR 2	p-value 2	BIC
VAR(1)	1.0578	0.3037	7.09	0.0078	-47860.1573
VAR(2)	0.3053	0.5806	0.3454	0.5567	-47173.6173
VAR(3)	0.186	0.6663	0.2309	0.6309	-47054.8558
VAR(4)	1.0348	0.309	3.775	0.052	-47046.5731
VAR(5)	1.0162	0.3134	0.8654	0.3522	-47019.6931

Table 7.19: Granger causality test results bank bond index

	Q6		Q7		all system
VAR(n)	LR 1	p-value 1	LR 2	p-value 2	BIC
VAR(1)	1.3573	0.244	12.8484	0.0003	-46762.1182
VAR(2)	0.0024	0.9612	0.663	0.4155	-46027.5248
VAR(3)	1.2318	0.2671	0.0859	0.7694	-45916.1854
VAR(4)	0.0354	0.8508	5.9026	0.0151	-45923.3114
VAR(n)	0.3948	0.5298	1.4062	0.2357	-45876.6666

Table 7.20: Results for the linear regression model of Barclays

Parameter	Estimate	t-statistic
$\hat{\alpha}$	-0.00472402908736815	-1.13313539760431
$\hat{\beta}_1$	-0.0319529062705964	-0.0234663691612001
$\hat{\beta}_2$	0.314171120442186	0.599654192608351
$\hat{\beta}_3$	-1.19375793761926	-5.77650321945787
$\hat{\beta}_4$	-3.31256746278327	-1.89736716083824
R^2 = 0.0394562999670610		

Table 7.21: Results for the linear regression model of Lloyds

Parameter	Estimate	t-statistic
$\hat{\alpha}$	-0.00392391210215231	-1.35705810300533
$\hat{\beta}_1$	-0.810899461954198	-1.15336131857568
$\hat{\beta}_2$	0.131196943969489	0.442249710204191
$\hat{\beta}_3$	-0.877609576166878	-4.89479229621805
$\hat{\beta}_4$	-1.59640625695908	-2.74029604898819
R^2 = 0.0769072028128279		

Table 7.22: Results for the linear regression model of Credit Suisse

Parameter	Estimate	t-statistic
$\hat{\alpha}$	-0.000113693205694542	-0.0681506636004940
$\hat{\beta}_1$	0.631529561550289	1.23094223576368
$\hat{\beta}_2$	0.384516381776108	1.31280311367218
$\hat{\beta}_3$	-1.05679957841556	-16.5032748069398
$\hat{\beta}_4$	-0.330259610835206	-0.595626455725809
R^2 = 0.262870040953006		

Table 7.23: Results for the linear regression model of UBS

Parameter	Estimate	t-statistic
$\hat{\alpha}$	-0.000365134843196180	-0.114707533014476
$\hat{\beta}_1$	0.982590814689094	1.23264021829020
$\hat{\beta}_2$	0.244193297730229	0.495178122559593
$\hat{\beta}_3$	-1.12959929576056	-12.5459233333497
$\hat{\beta}_4$	-0.383295244347346	-0.373124125199343
R^2 = 0.117705976091852		

Table 7.24: Results for the linear regression model of Unicredit

Parameter	Estimate	t-statistic
$\hat{\alpha}$	-0.00208111369211980	-0.362151299910510
$\hat{\beta}_1$	0.437303875287855	0.527565767855205
$\hat{\beta}_2$	-0.194505503432246	-0.543515664292793
$\hat{\beta}_3$	-1.81307436992135	-7.17409974550795
$\hat{\beta}_4$	-1.31947499949141	-1.37693780832525
R^2 = 0.160400142708117		

Table 7.25: Results for the linear regression model of all bonds index

Parameter	Estimate	t-statistic
$\hat{\alpha}$	-0.000440592621386152	-0.492692215607995
$\hat{\beta}_1$	0.0121491146833501	0.131640437916109
$\hat{\beta}_2$	-0.383024969001009	-16.1403861867866
$\hat{\beta}_3$	-0.0739136065063325	-0.402299687696603
R^2 = 0.356549817199584		

Table 7.26: Results for the linear regression model of bank bonds index

Parameter	Estimate	t-statistic
$\hat{\alpha}$	-0.00109443587004533	-0.817214251737434
$\hat{\beta}_1$	-0.0909803373013629	-0.683840780093922
$\hat{\beta}_2$	-0.459280032029211	-11.8678310682510
$\hat{\beta}_3$	0.0127196930391443	0.0428055538180904
R^2= 0.264238183340916		

8 Conclusion

This PhD thesis addresses the regulation of banks that perform financial intermediation. The financial stability objective applies to banks in particular that perform credit intermediation and deposit-taking. The stability of this intermediation is essential to an economy and thus is treated as a public good. Its promotion is the subject of a macro-prudential financial regulation framework; this includes regulatory agencies, such as central banks, and the corresponding macro-prudential tools. This PhD thesis contribution to knowledge is to stress that financial instability can also arise from non-bank financial institutions and corners of the global financial markets that are out of the reach of the regulatory agencies. Therefore, focussing exclusively on certain financial institutions may not mitigate financial instabilities sufficiently.

Chapter 2 analyses the causes of the global financial crisis of 2008. A bank can become a systemic threat even if its business is only indirectly exposed to a shock, as the case of Northern Rock demonstrates. It is merely because of the exposure to the rest of the financial system that a sudden drying up of refinancing conditions indiscriminately hits all banks alike. Regardless of the credit quality on its books, a bank can face serious distress with adverse refinancing conditions. So, even a well-managed bank is not exempted from fatal crises. Its collapse can be yet another link in the chain of contagion among banks leading towards a systemic crisis. Based on the results the two research questions throughout the thesis address first, how banks can be incentivised towards prudent business conduct, i.e. abstain from taking unsustainable risks in large quantities. Second, ways must be found to insulate banks against shocks from within the financial system.

Macro-prudential financial regulation must take this important insight into account. The comparative methodology in chapter 3 analyses the different interpretations of macro-prudence and the different initiatives to put macro-prudence into practice in the UK, the USA, and EU. First, for each of the three jurisdictions the new regulations that the regulated institutions have to abide by are analysed. Second, the regulatory architecture – i.e. who are the regulatory agencies – of each is analysed in regards to their ability to promote the common regulatory objective of maintaining financial stability. The chapter finds that the regulatory frameworks in the UK and EU are appropriate to put macro-prudence into practice. However, the approach in the USA is over-complex and competition among regulatory agencies bears the threat of prioritising turf wars over pursuing the objective of maintaining financial stability.

There are several new tools that a regulatory agency can employ. Chapter 4 gives an overview. With the new macro-prudential tools in the form of, for example, loan-to-value ratio the regulatory agencies can manipulate lending to sectors in the economy that have a history of creating asset bubbles like residential mortgage lending. Instead of cleaning up the damages after a bubble – with taxpayers money –, now the regulatory agencies can lean against the creation of bubbles in the first place. This is a direct intervention in the daily business of banks. The threat of unsustainable lending can be curbed.

Chapter 5 introduces the conditional Value-at-Risk, or CoVaR, as a measure to capture the co-movement of a single bank's losses and the losses of the banking system of which the bank is part of. The losses are defined as losses on their stock returns. More precisely the ΔCoVaR measures the difference of co-movement by comparing a state of tranquillity to a state of distress. For example the former is defined as the median, i.e. 50 per cent quantile, of a loss distribution and the latter are extreme losses, defined as the worst 5 per cent.

There are some surprising results. There is an overall tendency that the pre-crisis banks with low ranks stay there in the other periods. At the top, some banks remain systemic risk concerns, for instance BNP Paribas, others experience a sharp decrease in their respective ranking. For instance Deutsche Bank dropped from the top 10 to 25 after the crisis. In the pre-crisis mid-field there are banks that dramatically alter their ranking but no clear rule can be derived. For example, RBS decreased its systemic risk contribution from 21 to 33 during the crisis, but becomes the top risk in 2010. Crédit Agricole follows an opposite path from rank 25, to rank 2, to rank 17.

The ΔCoVaR shows how systemic risk moves but has no explanatory power as to what factors explain the movement. Thus, it is an observation tool complementary to the rest of the regulatory toolkit at the regulator's disposal to screen for financial institutions that can potentially pose a threat to financial stability. The empirical analysis suggests that individual banks can quickly become a systemic threat.

The contribution to knowledge is that the introduction of conditioning events into empirical research on systemic risk is an improvement to more simple measures such as the VaR. Furthermore, for the practitioner in the form of a regulatory agency the ΔCoVaR measure can become a tool to flag up those banks that appear to be a systemic concern. For example, the ECB could maintain a ΔCoVaR-based systemic risk map. If a particular bank is being flagged up, the ECB can commission the national regulatory agency to integrate the systemic risk calculations in their supervisory review of that bank. However, a further contribution to knowledge and practitioners is that due care must be exercised with the choice of length of the time series used to calculate a bank's systemic risk contribution. Depending on the time window of analysis, the systemic risk ranking of banks changes dramatically. This only reveals the fickle nature of systemic risk. Nevertheless, further improvement in terms of methodology and data input is a promising undertaking for future research.

In chapters 6 and 7, this thesis puts an emphasis on CoCos and how they can be designed to be a macro-prudential tool. In case the systemic risk measures presented in chapter 5 do not flag up a struggling bank, CoCos can abate distress without the direct intervention of a regulatory agency. CoCos are a new form of debt that, once triggered, de-leverages a bank immediately. Therefore it could be a strong asset within the macro-prudential toolkit of any macro-prudential regulatory framework.

Chapter 6 identifies the gaps in the literature and design flaws of existing CoCos. Macro-prudence is not exercised with these proposals. Banks are not incentivised towards prudence because a conversion of CoCos increases their loss-absorbency but there is no penality. However, chapter 7 proposes a design that does manipulate bank managers' incentive to be prudent and contains systemic risk stemming from a bankruptcy of a bank.

The empirical analysis in chapter 7 finds that there is no causality of the stock returns on CoCo spreads and vice versa. This is good news since the threat of feedback effects is abated. Otherwise CoCos that are embraced by policy makers would be counterproductive. If so they would be anything but macro-prudential; on the contrary, they would introduce instability. However, the analysis may be limited by the data. Complete CoCo data sets could only be obtained for five banks. For example it might well be the case that other banks' CoCos respond differently to the explanatory variables. For example, compare the results from the empirical CoCo analysis and the systemic risk ranking according to the ΔCoVaR methodology used in chapter 5, especially table 5.1. The results suggest that Unicredit's CoCo spread is caused by its stock returns volatility, at the same time it is the systemically most relevant bank in the same observation period. Unicredit was systemically relevant well before the observation period for the CoCos began, ranking 10th pre-crisis, 5th during the crisis, and 2nd post-crisis. The other banks in the sample rank much lower in the post crisis period. So, this suggests that when a bank becomes a systemic concern, outstanding CoCos could become counterproductive for stability. When the bank is not too severe a concern, markets' perception of its CoCos is more positive. Unfortunately, at this time the empirical results cannot be merged without technical difficulties. A promising idea for future research is to investigate whether the CoCo spread responds to the individual ΔCoVaR directly.

The second part of chapter 7 proposes an alternative design for CoCos: A debt-to-equity conversion with an exclusive call option for incumbent shareholders. First, the CoCo proposal introduces a swift penalty on a bank's management upon the trigger event. Second, the proposal is macro-prudent for it can easily play a role in a recovery and resolution programme. The CoCo is designed to convert debt into equity. However, the new equity does not remain with the original CoCo investors. Instead, incumbent shareholders are offered the new equity. In order to avoid a dilution of their claim in the bank's equity, they buy off the new equity at par from the CoCo investors. As the numerical example in section 7.3.4 shows, incumbent shareholders do experience a decrease in the return on equity, yet the bank is safer due to an increased loss-absorbency and the shareholders can increase their ownership in the bank. The former CoCo investors are bought out of the bank and face no loss, hence in terms of pricing, this CoCo proposal is a low-risk investment. From a strategical investment point of view, shareholders can increase their influence in a bank, alter the bank's strategy, and even replace managers. Exactly this is the swift penalty imposed on the bank's management that other CoCo proposals lack. The bank's management has good reason to steer the bank clear of the trigger event.

This chapter's contribution to theory is that CoCos can be designed to become a market-based instrument that addresses the debt overhang problem. This problem occurs when banks and incumbent shareholders are reluctant to inject further equity into a struggling bank, but doing so would save the bank and the shareholders' wealth. The underlying issue is that an injection would first benefit the value of outstanding debt and only then equity. CoCos with in the proposed form with an exclusive call option for incumbent shareholders provide a solution. At the same time this proposal is addressed at practitioners like macro-prudential regulatory agencies. In a recovery (going-concern basis) or resolution (gone-concern basis) process these CoCos are easier to provide a private sector solution than an intervention by a regulatory agency, possibly with taxpayers' money. Also, the regulatory agency only takes a passive role in the supervision of an orderly process of the reshaping of ownership.

In conclusion, with all the different measures that make the new regulatory frameworks, i.e. new regulations and new regulatory architectures, banks are made safer but not safe. However, they are just one part of the global financial system. The success of the regulatory agencies should be measured by maintaining the stability of such crucial services to the economy. Systemic risk can arise in other parts of the financial system to which the regulatory agencies do not have access to. Therefore the contribution of this PhD thesis is limited as well. Theoretically the proposed CoCos could be introduced to other non-bank financial institutions. However, this would require an active role of the legislation to impose such a tool. Yet, non-bank institutions that are not fully subject to a rigid regulatory framework do not have the incentive to introduce these CoCos.

Macro-prudence is a step forward to make banks safer. Yet, to policy makers and their regulatory agencies, the regulated banks, other market participants, and the public with their tax money, there is little relief in knowing that a definite answer to whether a macro-prudential framework can deliver, is just a financeal crisis away.

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